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Set of KPIs for MMFF Sector

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SUMMARY

The objective of WP7 is to build a benchmarking tool based on Key Performance Indicators (KPIs), that makes a validated numerical system to be recognised and used by the Mediterranean fish farming industry for its potential to reflect biological capacity, cost-efficiency, welfare-appropriate practices and environmental sustainability (KPIs system). The KPIs system in PerformFISH aims primarily to:

1. benchmark the technical efficiency of aquaculture companies and to identify sources of inefficiencies;
2. benchmark the entire MMFF operations and promote higher efficiencies and increased production with lower environmental impact;
3. assess the impact of PerformFISH results and solutions (feed, vaccines, hatchery and biosecurity protocols) deriving from WP2-WP6 on MMFF operations and KPIs (Task 7.3);
4. facilitate the recognition of criteria, standard and target for improving the performances and environmental sustainability of farming practices of Fish Farming companies as frame for the new Code (Task 7.4);
5. report on how MMFF sector demonstrates stewardship and creates and sustains value, mainly reporting environmental performances through KPIs;
6. implement decision-making throughout the lifetime of the project.

The benchmarking system has been prepared by ISPRA (P20), responsible for Deliverable 7.1. The preparation has been involving Fish Producer Associations (P3,4,5,6,21), their associated Linked Third Parties (LTPs) and several academic partners since the beginning of the project proposal. The consultation was a continuous process within the industry and it was extended for several months (and over the time expected, M9) in order to build a benchmarking system that reflects i) the differences in production systems and technologies used by the industry, ii) the different climate conditions at the different aquaculture sites across the Mediterranean and, more importantly, iii) the different industrial scales of the companies participating in the WP7.

The benchmarking system was designed to be applied to the whole production cycle of MMFF sector (boundaries), with the exclusion of the packaging and processing chain.

The PerformFISH benchmarking system integrates:

- the set of 55 Key Performances Indicators validated as A-level KPIs and ready to be used, approved by the MC and SC and ITEC group of PerformFISH project. Most of KPIs are Technical-KPIs (T-KPI) introduced to estimate the technical efficiency of companies, as far losses and diseases, deformities, feed efficiency, fish growth, use of chemicals. For grow-out production system only, a set of 9 Welfare KPIs (WE-KPI) was conceived for measuring fish welfare during farming in sea net pens and land-based tanks. A set of 14 Environmental KPIs (E-KPIs) was validated for recording numerical values on the impact of farming practices on marine habitat and biodiversity and the use of land, water, energy.
- an harmonised system to collect production data at Hatcheries, Pre-grow and Grow-out industrial installations. The methodology was validated with Partners (3,4,5,6,21) and LTPs

for the collection of numerical operational production values and benchmarking at batch, farm, and area level through the set of KPIs.

- *the WP7 - Standard Operating Procedures (SOPs)WP7- Collection of production data at industrial facilities for Key Performances Indicators*, which are published in D4Science web site, in the PerformFISH Gateway, PerformFISH KPI-VREs, along with five ms Excel data submission forms.
- A GIS based platform where ten year time series of Sea Surface Temperatures in °C have been collected from the Copernicus Marine Environment Monitoring Service (CMEMS) in order to classify the participating facilities into groups homogeneous for their temperature profiles.

The aquaculture industry collaborating in PerformFISH has committed to the principles of transparency, trust and data sharing, which are paramount principles that drive the preparation of PerformFISH and MMFF sectors strategy. The contribution of industrial partners to provide sensitive production data (KPIs G11, G12, G23, G24, G25) reveals their willingness to be open and to collaborate to establish a credible benchmarking system of MMFF sector performances through KPIs. In addition, several aquaculture Companies, not formally involved in PerformFISH, will participate on a voluntarily basis, with the support of national Producer Associations.

In total, 12 hatcheries and 21 pre grow/grow out facilities will be participating to the KPIs benchmarking system.

The KPI system is a core component of PerformFISH and will be used as a reference tool for the decision-making of processes, implementation of activities and impact assessment of the project. The WP7 will dedicate efforts to refine and improve the set of KPIs to reflect new data, improved practices and technologies in order to become a full benchmarking and decision-making tool for PerformFISH and beyond.

INTRODUCTION

Sea bass and sea bream are the second and the third fish species produced in Europe and represent 27,5% of European aquaculture, for a total volume of 178,300 ton in 2016 (FEAP, 2017). Greece is the main producer (59%) followed by Spain (20,7%), Italy (8%), Croatia (5,3%), Cyprus (3,6) and France (2%). Sea bass/sea bream farming contributes significantly to wealth and job creation in rural and coastal areas in the five EU Mediterranean countries represented in PerformFISH.

However, the overall growth of bass/bream sector in the EU has remained stagnant over the last decade, and the industry underwent to cyclic periods of boom and boost, which resulted in declining profitability across the sector and lower production volume than expected.



Sea bass production (tons) 2008-2016

PRODUCTION (tons) SPECIES	COUNTRY	YEAR									
		2008	2009	2010	2011	2012	2013	2014	2015	2016	
Sea Bass	TURKEY	49.270	46.554	50.796	47.013	65.512	67.912	74.653	77.000	72.342	
	GREECE	50.000	45.000	45.000	45.000	41.500	48.000	42.000	45.000	46.000	
	SPAIN	9.840	13.840	12.495	14.370	14.270	14.700	17.376	21.324	23.445	
	ITALY	9.800	9.800	9.800	8.700	7.200	6.800	6.500	6.450	6.800	
	FRANCE	3.968	3.204	2.779	3.000	2.300	1.970	2.021	1.980	1.928	
	CROATIA	2.700	3.000	3.200	2.785	2.375	3.014	3.500	4.500	5.291	
	CYPRUS	752	703	1.237	1.500	1.096	1.621	1.817	1.725	1.442	
	PORTUGAL	1.069	444	396	480	500	400	500	500	450	
	Total Sea Bass		127.399	122.545	125.703	122.848	134.753	144.417	148.367	158.479	157.698

Sea bream production (tons) 2008-2016

PRODUCTION (tons) SPECIES	COUNTRY	YEAR									
		2008	2009	2010	2011	2012	2013	2014	2015	2016	
Sea Bream	TURKEY	31.670	28.362	28.157	32.187	30.743	35.701	41.873	48.000	67.612	
	GREECE	94.000	90.000	74.000	63.000	72.000	75.000	71.000	65.000	59.000	
	SPAIN	23.930	23.690	20.360	16.930	19.430	16.800	16.230	16.231	13.740	
	ITALY	9.600	9.600	9.600	9.700	8.700	8.400	8.200	7.360	7.600	
	CYPRUS	1.600	2.572	2.799	3.065	3.121	4.444	2.919	3.656	5.136	
	CROATIA	1.800	2.000	2.000	1.793	2.105	2.466	3.640	4.500	4.304	
	FRANCE	1.636	1.648	1.377	1.500	1.300	1.477	1.105	1.502	1.671	
	PORTUGAL	1.635	1.383	851	1.200	1.000	1.500	1.500	1.400	1.500	
	Total Sea Bream		165.871	159.255	139.144	129.375	138.399	145.788	146.467	147.649	160.563



Figure 1: Sea bass and seabream production over the period 2008-2016 (FEAP 2017)

In 2014, the workshop at Aquaculture Europe concluded that the principal key performance indicators for sea bass/sea bream - growth, mortality and feed efficiency - have not progressed significantly over the last years (EAtiP, 2014) and this issue poses some concern for the sustainable development of the MMFF sector. *“More attention needs to be given by both the EU and relevant Member States to the urgent priority of improving technical performance of the Mediterranean fish farming sector, specifically of sea bass and sea bream. The absence of improvement over time is marked. Individual focused projects or a more holistic, integrated programme are required to address this, on both a short and longer term basis.....”* (FEAP Annual Report 2014).

In 2015, the result of the aquaculture industry’s consultation carried out in the ERA-Net COFASP project (Lane et al. 2016), specifically addressing the challenges and needs of salmon and sea bass and sea bream producers, highlighted that new approach models in R&D are needed to fuel improvements in juveniles quality, growth performances, feed ingredients quality and feeding, disease management and welfare and to increase profitability, viability and sustainability of sea bass and sea bream sector

(COFASP, 2015). Research and development projects in many areas of sea bass and sea bream aquaculture have been funded in the past years, both at national and international level, but very few have been directed at identifying solutions for industry and led to industrial scale implementation.

An innovative bottom-up approach was adopted in PerformFISH to respond to the MMFF needs and generate solutions to consolidate production practices.

Starting from the collaboration of the Fish Producers Associations of the 5 countries involved in PerformFISH, R&D partners and with the constitution of the Industry Technical Experts Committee (ITEC) group in representative of the Fish Producers Associations, PerformFISH build a benchmarking system, based on Key Performance Indicator (KPI) to perform the numerical assessment of technical performances of MMFF sector. It is the first time that the Fish Producers Associations and industry collaborate to share production data and to use a self-assessment management tool for measuring the technical efficiency and environmental performances of B&B companies within the MMFF sector, and towards other animal food production systems.

Main barriers to MMFF sector development

The main barriers and obstacles to consolidate the MMFF sector are recognised in PerformFISH project (Section 2.1.3, TA) as i) the diversity of biological and production systems across the Mediterranean, ii) the different geographical and climate conditions; iii) the lack of common industry standards. The complexity of the production landscape, both in terms of geographical conditions and production systems across the MMFF sector, the variable nature of the inputs, the variation in farm management, and poor data quality available, make measurements of performances of the MMFF sector a tough task.

Expected Impact	Barriers/Obstacles	Measures to Optimise Impact
To consolidate Mediterranean Aquaculture production for Key species towards a commercial scale, through sustainable fish farming and valuable seafood production.	<ul style="list-style-type: none"> ▪ Diversity of biological & production systems; ▪ Geographical conditions; ▪ Lack of common industry standards; ▪ Difficulty and delay in uptake and transfer of knowledge/technology to industrial applications. 	<ul style="list-style-type: none"> ▪ Develop standardisation through KPI monitoring system; ▪ Broad Industry Collaboration ▪ Generation of management tools and flexible production solutions; ▪ Focusing on key species; ▪ Collaborative Industry and RD&I experiments will promote knowledge transfer one on-one training; ▪ Tailor-made training

Table 1. Synthesis of impacts and related barriers and measures to optimize impact.

The Mediterranean aquaculture fish sector is characterized by a high degree of **diversity of biological and productions systems**, technologies, geographical conditions and environments. Different stages of maturity characterize aquaculture companies across the Mediterranean basin. There are small and medium enterprises (SMEs) scattered along Mediterranean coasts, typically national oriented, as well as, larger organizations emerged to consolidate business enterprise structure (mainly in Greece), nowadays producing more than 50% of European production of European Mediterranean bass/bream. National industries are operating under different political and environmental frameworks, which have influenced the development of production systems, farming technologies and business strategies. Geomorphological characteristics of the country and the availability of natural water resources also

have influenced the choice of production systems and aspects of production cycles. For sea bass and sea bream production, which represent about 98% of the entire MMMFF sector, the following production systems are in use:

1. Marine hatcheries, equipped with recirculation water system and/or open water system producing juveniles with different breeding programmes and in some cases using marker-assisted selection programme;
2. Pre-grow farming systems for juveniles, usually in land based farms using tanks and raceways;
3. Grow out farming systems in sea cages, mainly located in coastal waters, although in very different geographic, climatic and environmental conditions;
4. Grow out farming in land-based tanks or ponds, equipped with open flow water systems, using both marine or geothermal water sources, and partially recirculated water systems in a few cases.

Different production protocols and input are used, for example in feeds and feeding protocols, raw materials for self-feed preparation, health management practices and vaccination programme, size of stocking and size of delivered fish on the market.

Geographical and climate conditions also differ across Mediterranean area and these influence the regime of water temperature and hydrodynamic conditions in the different aquaculture sites across the Mediterranean. Water temperature plays a key role in biological processes and influences biological performances and ultimately the productivity and efficiency at farm level. A first analysis for sea surface temperature in the Mediterranean region based on Copernicus satellite data was carried out by ISPRA in collaboration with the Mediterranean Centre for Climate Change (CMCC). Time series of mean seasonal sea temperature were recorded in 10 aquaculture farming areas located in Greece, Spain, Italy and Croatia, where aquaculture companies participating as associated Third parties in PerformFISH are based. These time series of 30 years data provide further evidence on the different seasonal water temperature regimes across the Mediterranean sites. Therefore, the analysis of KPIs data recorded at industrial facilities, that are located in different farming sites characterised by different regime temperatures, is elaborated also considering sea water temperature at farm level.

The third and important factor impacting on the development of MMFF sector is the availability of **sector data and the quality of data** for sea bass/sea bream aquaculture in the Mediterranean area, which limits the understanding of biological, technical and economical drivers influencing the sector. The lack of these data has been a serious bottleneck for the construction of a benchmarking tool and to identify targets and industry standards for the sector.

Statistical data on European aquaculture production are collected on annual basis at country level (EU data Collection framework; Reg. 762/2009) and also provided by the Federation of Aquaculture Producers (FEAP) and FAO (SIPAM-GFCM). All data are aggregated data sets, thus not suitable to inform decision at farm level. Data on sector performances for bass/bream are not available. In other modern aquaculture industry, such as salmon farming in Norway, where industry production statistics are reported also at country level, information available includes either production data and information on fish inputs, harvests and sales, production losses. Annual company reports are published and available on line and management and technical standards used at company level are available (eg for aspects related to escapee and fish containments, MBA, 2017). The reference model for sea bass and sea bream industry is the salmon aquaculture industry, where collaborative actions across the salmon farming sector and with stakeholders, together with the use of appropriate data recording system and IT tools, allow the monitoring of input and output (e.g. fish meal and fish oil, mortalities, escapes, use of antibiotics). This facilitates the benchmarking of industry performances and the communication of the progress towards responsible aquaculture production practices adopted by salmon industry to market and consumers.

The benchmarking system, developed in WP7 and used in PerformFISH is aimed at provide operational values of KPIs that can inform on the biological capacity, technical efficiency and environmental sustainability of MMFF sector (task 7.3) and to identify targets for the company and ultimately common industry standards for MMFF sectors (Task 7.4).

THE SET OF PERFORMFISH KEY PERFORMANCE INDICATORS (KPIs)

Background

The first exercise to develop specific Key Performance Indicators (KPIs) for Mediterranean aquaculture sector began in 2016, during the preparation phase of PerformFish proposal and two meetings were organised in Athens (January 2016) and in Rome (June 2016).

The R&D partners and the high level technical advisory group of leaders of Fish Farm Associations (ITEC) from across the MMFF participated in both meetings and provided a first list of core KPIs that impact upon efficiencies and sustainability throughout the production cycle. The initial core set of KPIs includes those mentioned in the call SFS23, i.e. *mortalities*, *growth rate* and *feed efficiency* for the key species, European sea bass (*Dicentrarchus labrax*) and gilthead sea bream (*Sparus aurata*).

A set of operational values of core KPIs was compiled by fish farming companies, i.e. 10 hatcheries, 9 marine cage farms + 1 land-based flow through farm, to get the first numerical values of technical performances of MMFF sectors. The data provided a real-time analysis across the industry with current operational values and gave a first baseline that will be used to establish realistic quantitative targets for production and to evaluate the success of PerformFISH results on operational performances.

KPI: Losses per species and cause- percentage

The mortalities and losses should refer to closed batches at harvesting of 400g final weight



Gilthead sea bream	min	max	median	average	SD
% Mortalities	5.00%	20.00%	13.41%	12.97%	5.04%
% Unaccounted losses	-0.60%	22.10%	10.00%	8.17%	6.09%
% Total losses	12.00%	27.60%	20.00%	19.88%	4.48%



European sea bass	min	max	median	average	SD
% Mortalities	10.00%	20.00%	16.64%	16.07%	2.93%
% Unaccounted losses	-1.78%	24.80%	5.00%	7.40%	7.01%
% Total losses	15.00%	40.00%	23.41%	23.36%	7.21%

Figure 2: Example of KPIs for losses from the pre-exercise carried with ITEC and farm companies (2016)

This first exercise of data collection and comparative analysis of KPIs values provided by different aquaculture companies, however, highlighted also a number of sensitive points and gaps to be strengthened and filled in PerformFISH. Main gaps are related to: 1) a common consensus on a list of KPIs; 2) the definition of each KPI and the formula for the calculation; 3) the methodology to be used for data recording at farm level which differed in the aquaculture companies involved in the survey; 4) the critical control points during the production cycle and the most appropriate time intervals for KPIs data recording at industrial facilities.

The choice of KPIs in PerformFISH

Key performance indicators (KPIs) are defined as a set of quantifiable measures that a company can use to gauge its performance over time. These metrics are used to determine progress in achieving strategic and operational goals, and to compare performances against other businesses.

The work carried in task 7.1 was to set a list of realistic KPIs to cover aspects of health, growth, feed efficiency, fish welfare and environmental sustainability and to standardized a methodology for KPI data recording at aquaculture farms participating as Third Linked Parties (LTP) of the Fish Producers Associations (P3,4,5,6,21) in PerformFISH project.

The following four categories of key performance indicators were considered in PerformFISH:

- **Key Technical Performance Indicators (T-KPIs)** to measure biological performances and technical efficiency;
- **Key Economic Performance Indicators (EC-TPIs)** to measure productivity and efficiency of aquafarms;
- **Key Environmental Performance Indicators (E-KPIs)** to measure the impact of fish farming operations on the conservation of biodiversity and habitats, the use of natural resources, water, space and energy use;
- **Key Operational Welfare Performance Indicators (WEKPIs)** to measure fish welfare of sea bass and sea bream in relation to husbandry practices.

The majority of T-KPIs, Ec-KPIs and WE-KPIs are typically metrics utilised for bass and bream aquaculture sector and are used as Sector metric, while E-KPIs are common measurements across different sectors and used for benchmarking with other food animal production sectors (System metric).

The KPIs measurement in PerformFISH is primarily to:

- to benchmark the actual performances and efficiency of B&B companies
- to define target, as the level of performances that is needed to reach, according to best performance and desirable target outcomes
- to identify source of inefficiency in production cycles
- to analyse how solutions and results (feed, vaccines, hatchery and biosecurity protocols..) generated in PerformFISH (WP1-6) will improve the performances and contribute to better production efficiencies, profitability and environmental sustainability of the MMFF sector

The set of KPIs will be used to inform decision at different levels

- ✓ benchmarking performances of farming units at company level (Company KPIs)
- ✓ benchmarking performances between companies (Sector KPIs)
- ✓ benchmarking performance vs other food animal production sectors (System KPIs)
- ✓ for setting industry standard for MMFF sector

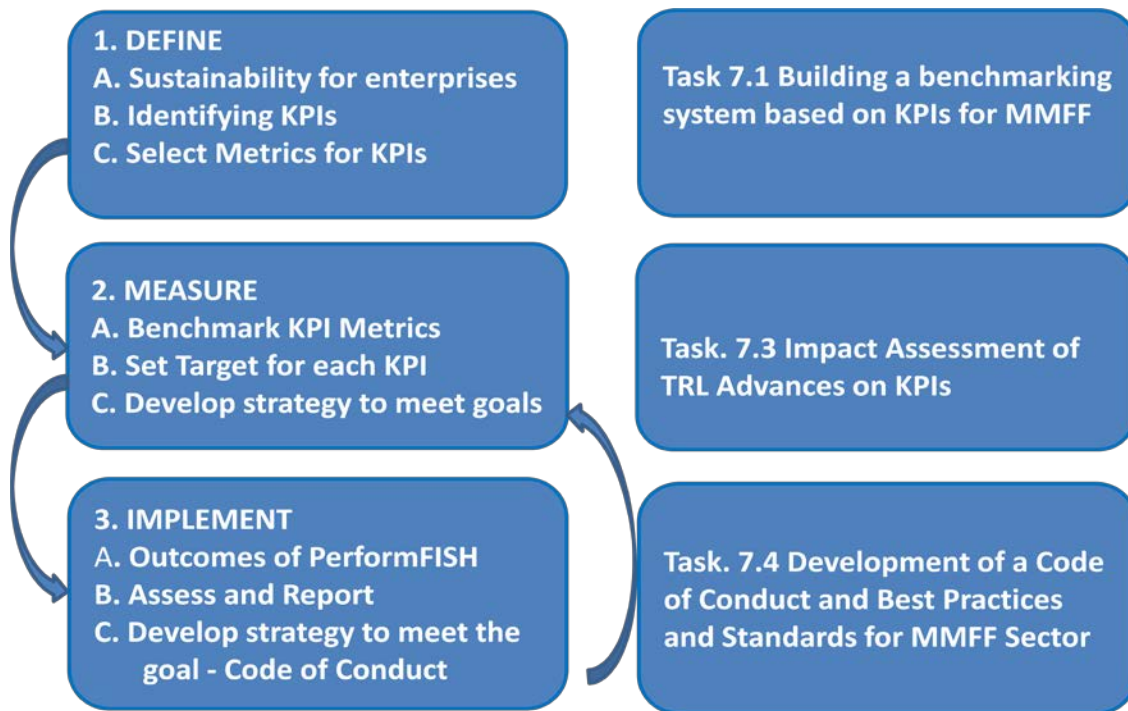


Figure 3. Methodological approach for construction and use of Key Performance Indicators in PerformFISH Project (modified by Matlock, 2017)

METHODOLOGY

Building of the PerformFISH KPIs

To select the appropriate set of KPIs, an iterative and participatory process was carried out in close collaboration with the Fish Producers Associations and the ITEC and R&D partners. A preliminary selection of relevant KPIs was presented at the project kick-off meeting (Volos, May 2017) and a dedicated workshop was held in Rome, (November 2017) to identify and validate the set of KPIs to be used in PerformFISH (**Milestone 7.1 at M6**). The final set of KPIs has been validated by PerformFISH consortium at M12, within the annual project meeting held in Gran Canaria on the 1st June 2018.

The Key Performance Indicators workshop (M.7.1)

The Key Performance Indicators workshop was held in Rome at ISPRA headquarter on the 9th of November 2017, with 37 participants from 7 EU countries.

The main objective of this meeting was the identification of the set of relevant KPIs to be used in PerformFISH to assess the technical efficiency and the sustainability of the B&B companies, and the definition of a common methodology to collect KPI data on farm, to ensure that different farmers and managers across the Mediterranean will provide accurate and reliable KPI values. Good quality data and appropriate time series were recognized to be essential to benchmark performances through KPIs at a farming unit level, at farm level and between companies.

A draft report of DL7.1 was prepared by Giovanna Marino (WP7 leader) and by ISPRA team and delivered to all participants before the meeting to introduce: i) the criteria used for the selection of KPIs; ii) the productions systems and the critical points for each production system to be considered; iii) a tentative list of KPIs selected for each production system; iv) the definition of each KPIs and the formula for the calculation; v) the parameterization for data collection; vi) the source of data.

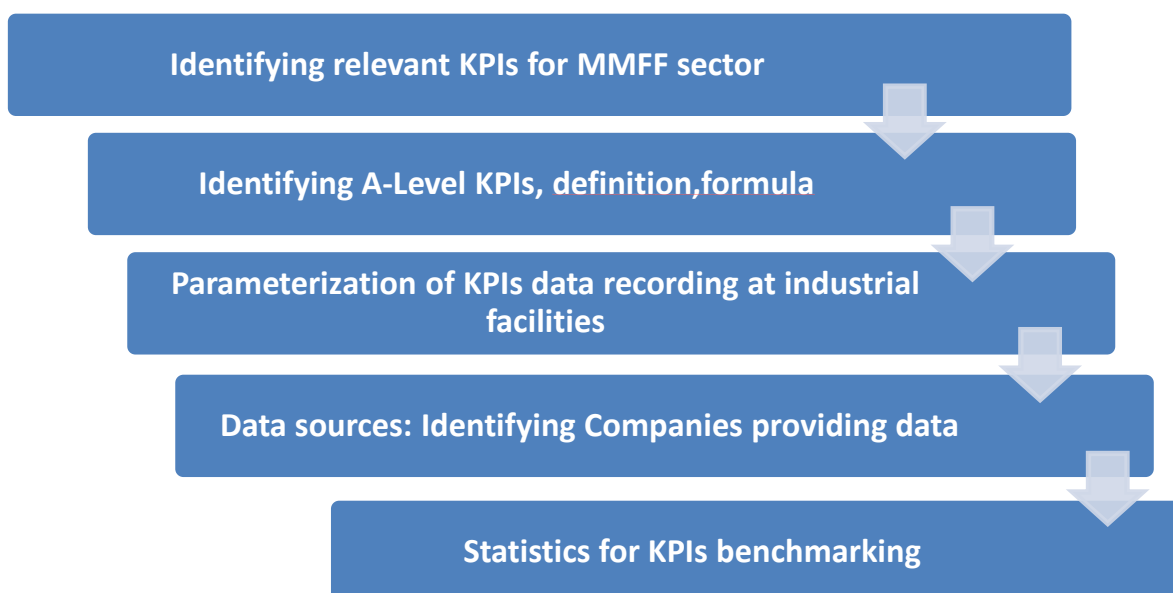


Figure 4: Scheme of the methodology adopted to define the KPI benchmarking system

i) Identifying relevant KPIs to be measured in PerformFISH

The spectrum of aquaculture KPIs of potential interest for MMFF sector is very wide.

To select the most relevant KPI, the SMART criteria, which letters stand for Specific, Measurable, Attainable, Relevant, Time-bound, were considered.

The PerformFISH KPIs have been selected to be:

- Relevant and performance oriented
- Easy to understand
- Measurable (formula)
- Attainable (easy to collect high quality data set)
- Achievable in a reasonable time-frame (production cycle/year)

The set of KPIs also responds to the following criteria:

- Outcomes Based
- Science Driven
- Technology Neutral
- Transparent

According to these criteria, the process to develop the set of KPIs started from the identification of critical successful factors for the different production systems used in Europe for farming European sea bass and gilthead sea bream. Three production systems were considered:

- Marine hatchery
- Pre-grow out system
- Grow-out farming system

The critical successful factors (input) and the critical control points for Hatchery, Pre grow and Growth out systems were presented during the WS and analysed as the key area that have to be controlled and measured during production cycle through KPIs (data not reported here).

The critical control points were used for the parameterization of data recording for KPIs.

The list of KPIs presented by ISPRA at the meeting included 145 indicator metrics (Table2). The list included

i) the first list of core KPIs for hatchery

ii) the list of core KPIs (growth, mortality and feed efficiency) at grow-out stage, already put in place and analysed by ITEC from the beginning of the project;

iii) a new set of indicator metrics to complementing the list of core KPIs and intended to measure efficiency, fish welfare and environmental sustainability of farming practices adopted by MMFF sector.

KPI category	Indicator metrics	n	
Hatchery	Hatchery Total Productivity	10	33
	Hatchery production	3	
	Hatchery deformities	5	
	Hatchery Growth	4	
	Hatchery feed Costs	5	
	Hatchery Health Costs	6	
Pre grow	Pre grow total productivity	8	24
	Mortalities KPI-Losses per species and cause	3	
	Growth-KPI	3	
	Feed efficiency-KPI	2	
	Health costs-KPI	8	
Grow out Health Feed Growth	Mortalities KPI-Losses per species and cause	4	22
	Dependency on antiparasitic treatments- KPI	3	
	Dependency on antibiotic treatments- KPI	3	
	Growth rate KPI	3	
	Feed efficiency KPI	2	
	Health costs-KPI	5	
	Economic KPI	2	
Grow out Environmental	Preservation of biodiversity and habitats - KPI	6	27
	Responsible Use of Resources -KPI	8	
	Responsible Use of Chemical and Vet Drugs - KPI	9	
	Protection of Aquatic Animal Health -KPI	4	
Grow out Welfare	Animal based welfare – KPI	20	39
	Indirect-welfare indicators	19	
			145

Table 2. First list of indicator metrics proposed at *Key Performance Indicators workshop* (Rome, November 2017)

New metrics and indicators were presented and discussed for the first time at WS among ITEC and scientific partners. ISPRA prepared a form for each single indicator metric and requested the participants to provide written comments with regard to the relevance for sea bass and sea bream sector as KPI and its attributes:

- relevance
- definition
- formula for calculation
- metrics, as far as data and time series recording at farm/company level
- attainability, according to the production strategy of the company participating as Third parties of Fish Associations.

The workshop participants voluntarily gathered into 4 working groups, mainly according to their expertise. Each working group only dealt with a single category of KPIs:

WG1. Technical KPIs for Hatchery

WG2. Technical KPIs for Grow-out - Health, Growth, Feed

WG3. Fish welfare KPIs

WG4. Environmental KPIs

In each WG and KPI category, the set of KPIs were extensively analyzed and discussed, and notes were reported on each single KPI form, to be handed over to the ISPRA team to be finalized.

According to the criteria above reported, the initial set of KPIs (n. 126) belonging to the 4 categories was classified by working group as:

- **A Level - KPI to be readily adopted by and used in a first phase of the project.**
- **B Level - KPI to be revised to be adopted by and used from M24 of the project.**
- **KPIs discarded**

At the end of the discussion inside the 4 working groups, a reporter from each working group reported in plenary on the main issues emerged from the internal discussion, and a discussion in plenary followed.

ii) Identifying A-Level KPIs

On November 30th, a second report was drafted by ISPRA and sent to the WG's participants. The report analysed all revisions and suggestions elaborated and reported by the 4 WGs for each KPI.

The complete list of Technical KPIs (for hatchery system, for pre-grow and for grow-out in cage), Welfare KPI and Environmental KPI were reported and classified as A-level KPI, B- level KPIs and discarded KPIs, as deemed by WGs experts.

The participants of each Working Group were asked to check the KPI list and send their feedbacks and comments and to address critical issues identified by ISPRA to find a final consensus on the list of KPI validated at A level, on definitions and formula for calculation by 15th December.

Additional comments from ITEC experts and R&D partners who participated to different WGs or were not able to attend the Rome meeting have been also collected by e mail exchange, contacts and skype meetings. The comments received on each KPI, definition and the formula for calculation, were reviewed corrected and completed by ISPRA staff. The file generated was sent again to the Association of Fish Producers and ITEC. The number of KPIs deemed at A-level and B-level are reported in Table 3, however the list of KPIs was still not definitive, and final further refinement was made by Fish Producers Associations and ITEC in the following steps of the process.

KPI (n.)	A – level	B – level	Discarded
TE-KPI-Hatchery	20	2	11
TE-KPI-Pre grow	10	2	12
TE-KPI-Grow out	26	3	2
WE-KPI-Welfare	23	7	0
E-KPI-Environment	13	9	5
TOTAL	93	23	28

Table 3. KPI deemed as A- level KPIs, B level KPIs and discarded KPIs after the Rome meeting. The list of A-Level KPIs was revised several times by Fish Producers Associations and ITEC.

iii) Metrics - parameterization of KPI data recording at LTP facilities

The objective of this step was to identify a reliable methodology for recording KPI data to be used by all aquaculture companies participating as Third Linked parties of Producers Associations in WP7. It was performed in collaboration with Fish Producers Associations and the ITEC experts coordinating the WGs. The parameterization for recording production data at facilities was designed considering the diversity of biological cycles, production systems and technologies, and more importantly the different industrial scale of the companies participating in the WP7-KPI as third parties of Fish Producers Associations. According to the composition of ITEC, in PerformFISH coexist companies producing 40.000 ton per year and small companies cycle producing <400ton per year. Therefore, the methodology for data recording needs to be flexible and adapted to the different production systems and scale, fixing the KPI and the method for calculation.

The parameterization of data recording were not fully defined by the WGs for the different categories of KPIs at Rome meeting. It was recommended to perform data recording considering the period of fish stocking, water temperature and critical control points during the production cycle. For this reason, this step of parameterization of data recording for building the KPI system was quite long and has required many refinements to be consistent with the different requests presented by Producers Associations and LTPs involved in WP7.

The recording of KPI data was modelled for the three production systems:

1. Hatchery and Nursery
2. Pre-grow
3. Growth-out in sea net pens and land-based tanks

The parameterization was proposed according to the:

- **Period of stocking**
- **Size of stocking**
- **Critical control points:** fixed degrees days per hatchery;
fixed fish size (body weight) for grow out
- **Reporting:** batch level, farm level and area level

iv) Consultation process on KPIs

From December 2017 to April 2018, the set of level-A KPIs that will be used in hatchery, pre-grow and grow out systems as well as the methodology for recording numeric values for each KPI at industrial facilities have been reviewed several times by the Producer Associations (P3,4,5,6,21), scientific partners (P2, P12) and Third Linked parties.

During this period, ISPRA and the people responsible in charge for the five Producers Associations met regularly via phone and Skype meetings, where various experts and scientific partners of WP2,3 and 4 were consulted in order to refine draft indicators, formula and requirements for data recording at facilities.

The consultation was a continuous process within the industry and it was extended for several months in order to build a benchmarking system that reflects the differences in production systems and technologies used by the industry and, more importantly, the different industrial scales of the companies participating in the WP7.

The final set of KPIs to be used in the hatchery, pre grow and grow out production systems, the definition of each KPI, the formula for calculation, the way of data recording and the interval of data recording were presented in the first annual project meeting held in Las Palmas, Gran Canarie (30 May- 2 June) and was validated by the MC and SC of PerformFISH.

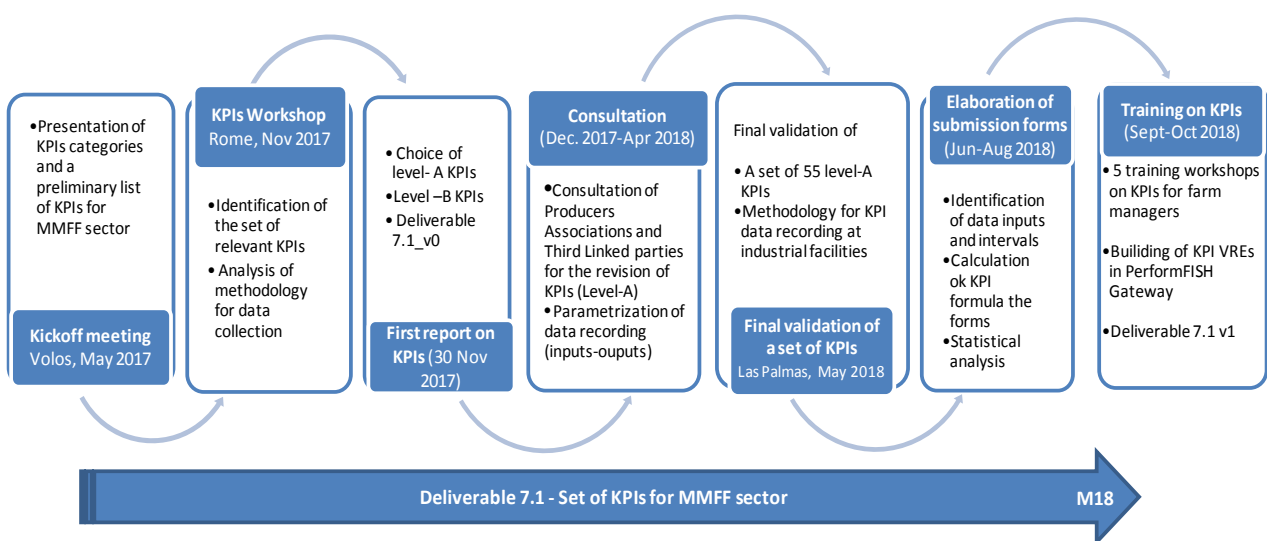


Figure 5. Step of the process of implementation of deliverable 7.1

iv) Training

Five one-day training workshops on the KPI benchmarking system were organised in collaboration with the Producers associations and Third Linked Parties involved in PerformFISH (Table 4 a,b).

The first training was organised by the Croatian Association (P6) in Croatia, Zadar, at Cromaris on 3rd of September and the last was held in Paris on October 11th and organised by the (P21) in Paris. Producers Associations and R&D managers and operators from LTPs that will be directly involved in the recording and submission of data in PerformFISH attended the meeting. In addition, 17 sea bass and sea bream companies, actually not involved as LTP in PerformFISH, also expressed interest to participate in the benchmarking tool and were invited accordingly.

The trainings were interactive sessions aimed at reviewing the list of KPIs, the methodology for data recording and the use of the submission forms, as excel datasheets, prepared by ISPRA for the recording and calculation of KPIs values. It was an useful exercise of dialogue with participants and an opportunity to clarify different issues and get their feedback to improve, refine and make more friendly the tool. The requests of farm managers were accepted, whenever possible, and the submission forms were modified accordingly.

How to use the D4Science e-Infrastructure and how to register and use KPI-VREs the interface and storage KPIs data (Task. 7.2), was presented remotely by Massimiliano Assante from CNR-ISTI (P23), during the meetings held in Athens and Paris. A webinar session on the KPI-VRE has been also organised by ISPRA and ISTI CNR for LTPs managers and Producer Associations from Croatia, Italy and Spain in November 2018, to explain the way of functioning.

The special requirements for the anonimization of the KPI data in the VRE and for avoiding the recognition of the farms in the KPI analysis and computation were requested by LTPs. VRE exploitation modalities and Privacy Policy, which are compliant with EU General Data Protection Regulation (GDPR), and PerformFISH ToU Policies were presented and discussed.

The timeline for data recording for the 2018-2019 production cycle was planned with LTPs. It was agreed that LTPs will provide production data from closed batches at seasons 2017 and 2018 to analysis background numerical values for KPI at company and farm level.

Source of data

Two main sources of data are available in PerformFISH and feed the KPI system: i) data collected at company level in industrial facilities; ii) data collected from experiments run in WP2-6.

Data recording in industrial facilities

The aquaculture industry collaborating in PerformFISH has committed to the principles of transparency, trust and data sharing, which are paramount principles that driven the preparation of PerformFISH and MMFF sectors strategy. The process to build the benchmarking tool is a participatory process to be carried out in close collaboration with the Producers Associations, ITEC and Academic partners. The collaboration between R&D and Industry is crucial to choice the appropriate indicator according to criteria, the formula for its calculation, the interval of measurements, and ensure a efficient and not time consuming data collection on farms.

Data collection is a responsibility of Producers Associations and associated companies participating in WP7. It's important that companies and managers involved in KPIs collection identify their needs and the time to allocate to data collection.

A questionnaire was delivered to Fish Producers Associations to get a preliminary list of bass/bream companies that will be involved in WP7 and KPIs, including information about the number of farm sites. The list of sea bass and sea bream companies based in Italy, Croatia, Greece and Spain that have expressed interest to participate in task 7.1

Boundaries of the KPI benchmarking system

The benchmarking system is designed to be applied to the whole production cycle of MMFF sector with the exclusion of the packaging, processing and marketing chain. The feed production and transport chain has been also not included in the computation and analysis of the KPIs (Boundaries).

The Technical, welfare and environmental KPIs will be then applied along the aquaculture production chain, from the fingerling production to the stunning and slaughtering process. This decision was taken considering the project's focus on production parameters as well as the possible difficulties in the data collection of feed production, transportation to and from the production site, packaging and processing, whenever these processes would be carried out by companies not involved in the benchmarking exercise or even not directly involved in commercial aquaculture production.

Tools for data collection

In order to facilitate the recording of uniform numerical values for KPIs and to guarantee the use of identical recording system among the companies, ISPRA developed a set of submission forms, in Ms Excel format, as a tool specifically designed for KPI data recording at Hatchery, Pre grow and Growth out production systems. The tool, which consists of 2 excel spreadsheets for each production system, was presented at the training workshops to make farm managers more confident with the electronic forms prepared and the methodology for data collection, recording and submission.

The KPI submission forms and the Standard Operating Procedures (SOPs) for data recording will be made available for download on D4Science web site, in the PerformFISH KPI-VREs.

Closed batches (2017-2018)

The PerformFISH Management Committee at the annual meeting (May, 2018), the Producer Associations and the LTPs agreed on the use of historical data (closed batches) to test the data recording system and to build a preliminary dataset of KPI as baseline for the KPI benchmarking system. Each LTP will record production data from closed batches, fill the submission form and upload it in the KPI-VRE. The following data are expected from each LTP involved in WP7:

- Hatchery - 5 closed batches, from three hatchery Periods, production cycles closed in 2017 and 2018.
- Pre-grow system - 5 closed batches, from three hatchery Periods, from production cycles closed in 2017 and 2018.
- Grow out system - 5 closed batches, from four Quarters, from production cycles closed in 2017 and 2018.

The closed batches are an important source of data, providing real numerical values of production for the calculation of KPI, and allow the test for the functioning of the KPI-VRE, the control of submission and calculation forms and finally the validation of the *beta* test version of the KPI-VRE, in progressing by CNR-ISTI. Closed batches data will be also useful for the first benchmarking with LTPs, at company and farm level.

The list of aquaculture companies participating as LTPs of Producers Association and the list of companies participating voluntary in KPI system is reported in Tables 4a,b according to the production system and culture technology (hatchery, pre grow, grow out in net pens, grow out in land based tanks).

HATCHERY (closed and semi-closed systems)						
Partner number	Participant name	Organisation	Company name	Type of partner	Country	Certification scheme (Ref. DL 10.5)
3.1	ALEVINES Y DORADAS SA		ADSA	LTP	Spain	GLOBALG.A.P. GGN 4056186237279
3.2	AQUICULTURA ELS ALFACS SL		ALFACS	LTP	Spain	
4.1	Selonda Aquaculture S.A.		Selonda	LTP	Greece	GLOBALG.A.P GGN 5206146000002
4.2	NIREUS ICHTHIOKALLIERGEIES ANONYMI ETAIRIA		NIREUS	LTP	Greece	GLOBALG.A.P GGN 5202957000002
4.3	KALLIERGEIES YDROVION ORGANISMON ANONYMOS ETAIREIA		ANDROMEDA	LTP	Greece	GLOBALG.A.P GGN 5200700699992
5.2	Panittica Italia Società Agricola Srl		PISASrl	LTP	Italy	GLOBALG.A.P GGN 4056186236159
5.3	AZIENDA AGRICOLA ITTICA CALDOLI		CALDOLI	LTP	Italy	GLOBALG.A.P GGN 4056186640673
6.1	Cromaris dioničko društvo za marikulturu		CROMARIS	LTP	Croatia	GLOBAL GAP GGN 4056186206817
21.1	FERME MARINE DU DOUHET SAS		FMD	LTP	France	GLOBALG.A.P GGN 4056186237118
21.2	ECLOSERIE MARINE DE GRAVELINES ICHTUS		EMG-Icthus	LTP	France	GLOBALG.A.P GGN 4056186235985
4			Kefalonia Fisheries SA	Others	Greece	
5			Acqua Azzurra SpA	Others	Italy	
5			Valle Cà Zuliani srl (RO)	Others	Italy	
5			Valle Cà Zuliani srl (GO)	Others	Italy	
21			LPDS - Aqualande	Others	France	
21			France Turbot Icthus – Gloria Maris	Others	France	
21			France Turbot Icthus - Gloria Maris	Others	France	

Table 4a. Hatcheries participating voluntary in KPIs system

PRE-GROW & GROW-OUT						
Partner number	Participant Organisation name	Company name	Type of partner	Country	Technology	Certification scheme (Ref. DL 10.5)
3.2	AQUICULTURA ELS ALFACS SL	ALFACS	LTP	Spain	Grow-out Sea net pen	
3.3	Andromeda Iberica Acuicultura S.L.	Androlberica	LTP	Spain	Grow-out Sea net pen	GLOBALG.A.P GGN 4052852343060
4.1	Selonda Aquaculture S.A.	Selonda	LTP	Greece	Grow-out Sea net pen	GLOBALG.A.P GGN 5206146000002
4.2	NIREUS ICHTHIOKALLIER GEIES ANONYMI ETAIRIA	NIREUS	LTP	Greece	Grow-out Sea net pen	GLOBALG.A.P GGN 5202957000002
4.3	KALLIERGEIES YDROVION ORGANISMON ANONYMOS ETAIREIA	ANDROMEDA	LTP	Greece	Grow-out Sea net pen	GLOBALG.A.P GGN 5200700699992
5.1	Soc. Agr. Cosa	COSA	LTP	Italy	Grow-out Land-based tanks	Occupational Health and Safety Management System Standard OHSAS 18001:2007
5.3	AZIENDA AGRICOLA ITTICA CALDOLI	CALDOLI	LTP	Italy	Grow-out Land-based tanks	GLOBALG.A.P GGN 4056186640673
6.1	Cromaris dioničko društvoza marikulturu	CROMARIS - Kosara	LTP	Croatia	Grow-out Sea net pen	GLOBAL GAP GGN 4056186206817
6.1	Cromaris dioničko društvoza marikulturu	CROMARIS – Velo Zalo	LTP	Croatia	Grow-out Sea net pen	GLOBAL GAP GGN 4056186206817
21.1	FERME MARINE DU DOUHET SAS	FMD	LTP	France	Pre-Grow Land-based tanks	GLOBALG.A.P GGN 4056186237118
3		Culmarex SI	Others	Spain	Grow-out Sea net pen	
3		Albaladejo SI	Others	Spain	Grow-out Sea net pen	

4		Kefalonia Fisheries SA	Others	Greece	Grow-out Sea net pen	
5		Civita Ittica srl (RM)	Others	Italy	Grow-out Land-based tanks	
5		Civita Ittica srl (LI)	Others	Italy	Grow-out Sea net pen	
5		Maribrin srl	Others	Italy	Pre-Grow Land-based tanks	
5		AQUA di Roberto Cò	Others	Italy	Grow-out Sea net pen	
5		Agroittica Toscana (LI)	Others	Italy	Grow-out Sea net pen	
5		Acqua Azzurra SpA	Others	Italy	Grow-out Sea net pen	
5		Valle Cà Zuliani srl	Others	Italy	Grow-out Sea net pen	
5		<i>Rehomare srl</i>	Others	Italy	Grow-out Sea net pen	
21		<i>Acquacoltura Palma d'oro - Gloria Maris</i>	Others	France	Grow-out Sea net pen	

Table 4b. Pre grow and Grow out companies participating voluntary in KPIs system

KPIs recorded in experiments run in WP2-6.

There are a 2-ways interactions of WP7 with other technical WPs of PerformFISH. From one side, the KPI data collected during routine cycles at hatcheries and grow-out industrial facilities in WP2-WP6 that are relevant for the KPIs used in WP7 will complement the benchmarking system. On the other side, KPI data collected in experimental trials run in WP2-WP6 for testing innovative solutions (e.g. innovative hatchery protocols, feed ingredients and diets, disease managements procedures and medicine and bioactive products) will be tested against the KPI values recorded in WP7 at industrial facilities. This benchmarking analysis will be part of the impact assessment analysis of PerformFISH (task 7.3).

WP2 - Juveniles Quality and Growth Potential - An extensive production data collection during the larval rearing period will be carried out at the industrial hatcheries (P3,P4,P5,P21) involved in WP2 (Task 2.2.1, 2.2.2) in 2017-2018. This first exercise in WP2, will be useful to test the feasibility of data recording and sampling and to make more efficient KPI data recording in WP7 for the next hatchery cycles (2018, 2019, 2020). Biological samples collected at batch level and analysed in WP2 for growth, survival, deformities will be used as complement background data for implement KPIs validated for hatchery and for specific KPIs (type of deformities and severity).

WP3 – Boosting Fish Health at all Lifecycle Stages - The task 3.1 will record data through a survey on mortalities in routine cycles and on the most relevant pathogens of bass/bream during grow out farming. Information collected will be organised to be used as background data to complement Health-KPIs related to losses (KPI total mortalities, mortalities by specific disease etc) collected at industrial facilities in WP7. As far as welfare KPIs, the task 3.5 will validate some direct animal-based indicators at industrial facilities, in collaboration with companies and ITEC experts that have expressed interest in this

task. From M36 the most relevant animal-based welfare KPI validated in task 3.5 and actually deemed as B-Level KPIs will be upgraded in the KPI benchmarking tool of WP7 as A-level KPIs.

WP4 – Efficiency Feeds to improve the Current KPIs in production System -Several experiments will run in WP4 for searching alternative sources of feed ingredients and innovative feeding strategies. Some technical KPIs related to fish growth, feed efficiency and welfare will be collected during the experiments; KPIs values from these experiments will be compared with KPI value recorded at batch levels in routine cycle at industrial facilities in WP7.

WP6- Testing and validation - Relevant results from experimental trials carried out in WP2-6 will be tested at commercial scale in industrial installations to be validated in real farming environment from M36, in collaboration with Fish Farming companies and Academic partners. KPI values collected in WP7 will be used as benchmarking to evaluate the *impact assessment* of these new solutions and outcomes tested in WP6. For each KPI, the list of experiments organised in different WP-tasks which may contribute with numerical values to the KPI are detailed in the single KPI form.

Statistical analysis

1. Definition of the minimum sample size

A minimum sample size, at batch level, was defined in order to get reliable data collection.

In particular, a minimum number of representative batches in each farm was carried out to obtain statistically significant results (Raheli et al. ,2017).

In general, given v companies ($v: 1, 2, \dots, z$) and k j farm ($j: 1, 2, \dots, m_r$)

Let:

- n_{vj} the number of batches to be monitored in the j^{th} farm belongs at v^{th} company
- N_{vj} the number of total batches belongs at j^{th} farm belongs at v^{th} company
- s_{vj} the estimated standard deviation of variable target (e.g. the survival rate %) in the j^{th} farm belongs at v^{th} company
- t the value of t-Student at 95% of the confidence interval
- d the acceptable error of the efficient estimate (generally 5%)

It was defined the following minimum sample size

$$n_{iv} = \frac{N_{iv} * (s_{iv} * t)^2}{(N_{iv-1}) * d^2 * (s_{iv} * t)^2}$$

The data collection will be carried out on this minimum number of batches for each farm (j) of the company (v).

2. Analytical KPI formulas

In general, a generic KPI is expressed as ratio between two or more variables observed during the survey.

Let

X_{kj} the given variable detected on the k^{th} batch of j^{th} farm

Y_{kj} the given variable detected on the k^{th} batch of j^{th} farm

The i^{th} KPI can be defined as

$$KPI_{i(kj)} = \frac{X_{kj}}{Y_{kj}} * 100$$

Where $i: 1, 2, \dots, q$

$k: 1, 2, \dots, h_n$

$j: 1, 2, \dots, m_r$

3. Descriptive statistical analysis

The data collected and the KPIs defined in point 2 will be analysed using basic statistical analysis techniques which allowed their graphical and tabular representation. In particular, were calculated position and variability indices both at general level and that at stratified level (e.g by quarter). The position indices considered were: minimum value, first quartile, median, mean, third quartile and maximum value while the variability index involved were the standard deviation, the range and the inter quartile interval .

The graphical representation of some or all of those indices was made at the general and/or stratified level (e.g. by quarter) and concerned the choice between different plots such as the scatter plot (using KPI target or KPI dimension), the box plot (using single KPI) and the graphical output of DEA (using KPI target or KPI dimension).

4. Data Envelopment Analysis (DEA)

DEA is a non parametric method based on linear programming model used in economics for the estimation of productive efficiency of decision making units (DMU) (Cook, Tone and Zhu, 2014). DEA is considered as a transformation function (rate) of multiple inputs into multiple outputs and, the resulting ratio can be interpreted as an overall measure of technical efficiency of the unit. This ratio is a number between 0 and 1, where 1 represents full efficiency and values ≤ 1 indicates that inefficiency is present. Unlike from other techniques, DEA permits to measure relative performance of different DMUs, considering multiple inputs and outputs at the same time as follows:

$$\max \frac{\text{Weighted (Input 1 + Input 2 + \dots + Input n)}}{\text{Weighted (Output 1 + Output 2 + \dots + Output n)}} \quad [1]$$

This analysis is applied for measuring the DMU's efficiency through the modelling of one theoretical benchmark unit, which is obtained from [1] by using the DMU observed.

The output of DEA provide a chart in which the units are plotted in a plane generates by the input/output ratios; a virtual line (or frontier) in the chart represents the maximum output that can be produced given the inputs [1]. The frontier sets the boundary between the efficiency and inefficiency and, efficient DMUs are plotted along this line while inefficient ones at increasing distance from it. Then efficient or inefficient DMUs can be individuated by deviation from the frontier, which designates the performance of the best DMUs and measures the efficiency of other DMUs as deviations from it (Fig1).

For the application in PerformFISH benchmarking system, application of DEA can be performed at batch, farm, company and area level. These levels represent the DMUs. Input and output parameters to be included in the DEA, are defined through the KPIs that determine the efficiency of the batch (if DMU = Batch), of the farm (if DMU = Farm), of the company (if DMU = Company) or of the area (if DMU = area). As reported by Bogetoft and Otto (2011) the classic method of DEA includes six models that can be used to estimate the efficiency, shortly:

A) The constant return to scale (CRS) that is applied when an increase (or decrease) of the inputs follows a proportional increase (or decrease) of the outputs.

B) The increasing return to scale (IRS) that is applied if an increase (or decrease) of the inputs follows an increase (or decrease) of the outputs more proportional than (e.g. exponential)

C) The decreasing return to scale (DRS) that is applied if an increase (or decrease) of the inputs follows an increase (or decrease) less than proportional output.

D) The **Variable returns to scale (VRS)** helps to estimate efficiencies whether an increase or decrease in input or outputs does not result in a proportional change in the outputs or inputs respectively. This method includes both increasing and decreasing returns to scale.

E) The free disposable hull model (FDH) is based on pairwise comparisons. It uses a pure dominance criterion, but has otherwise no additional flexibility. The FDH model is based on deterministic (or observed activities) and free disposability postulates. It is not a convex model. One appealing characteristic of FDH model due to non convexity nature of FDH efficiency frontier is that, differently from the previous models, in FDH model targets correspond to observed units and not to theoretical unit.

F) The free replicability hull models (FRH) keep the entity of the units by only adding integer multiples units. It considers integer combinations of DMUs in order to create a theoretical unit.

Once the most appropriate model of the DEA is chosen, on the basis of the assumptions that can be formulated both on the relationship between the input and output KPIs and on the definition of the reference DMU (observed or theoretical), the technical efficiency is calculated in correspondence of each DMUs. This efficiency can be studied, at a second stage of analysis, as a function of some input KPIs and other factors (expressed as dummy variables) by the application of techniques of analysis of ordinary least square regression (OLS) or Tobin regression.

Storage of KPI data and access

The pre-exercise carried out by bass/bream companies in 2016, highlighted the necessity to develop an IT tool to record, storage and compare the KPI data collected at industrial facilities. The D4Science infrastructure developed at CNR-ISTI in the course of more than 10 years, hosts the PerformFISH Gateway and a dedicated Virtual Research Environment (VRE) named PerformFish-KPIs. This KPI-VRE has been designed by CNR-ISTI (P) and ISPRA to support the uploading, validation and management of usage policies for Farms, Companies, and Associations (Task 7.2).

The PerformFish-KPIs VRE has setup as follows

- i) a storage system (Workspace) to store user's data with private-access policy to preserve the privacy of the data system (workspace for each COMPANYY)
- ii) a web interfaces allow managing and validating user-uploaded submission
- iii) a computational system to operate the validation of the files
- iv) a repository for the KPI database
- v) a computational system to operate the anonymization/publication of files
- vi) algorithms for comparative and descriptive statistics.

PerformFish-KPIs VRE access is on demand by users registered to the e-Infrastructure. The access and exploitation of the PerformFISH services for Gateway users is regulated by Terms Of Use upon registration; the Gateway Privacy Policy is compliant with EU General Data Protection Regulation (GDPR).





VRE for COMPANYY: In the PerformFish-KPIs VRE, CNR-ISTI is going to created a workspace for each LTP and aquaculture companies for storage of excel submission forms, for data mining and KPI calculation at company level.

VRE for PRODUCERS ASSOCIATIONS: A workspace created exclusively for Producers Associations (P3,4,5,6,21) will storage the KPIs considered by the PerformFISH Consortium at high level of confidentiality. Anonimization, analysis and outputs of these six KPIs will be make available only for Producers Association only.

VRE for WORKPACKAGES: In the PerformFish-KPIs VRE, CNR-ISTI will create additional workspaces for storage of data collected in other workpackages of the project, namely WP2,3,4,6, for. Performances of data collected in experimental trials run in WP2-WP6 for testing innovative solutions (e.g. innovative hatchery protocols, feed ingredients and diets, disease managements procedures and medicine and bioactive products) will be tested against the KPI values recorded in WP7 at industrial facilities. This benchmarking analysis will form part of the impact assessment analysis of PerformFISH (task 7.3).

Documents for initials submission with instructions and new submissions

Empty forms

-  Hatchery_Individual_Batch_Data_Entry_KPI.xlsx [Download](#)
-  Hatchery_Aggregated_Batch_Data_Entry_KPI.xlsx [Download](#)
-  Hatchery_Aggregated_Batch_Data_Entry KPI CLOSED BATCHES.xlsx [Download](#)
-  Hatchery_Individual_Batch_Data_Entry KPI CLOSED BATCHES.xlsx [Download](#)

Instructions:

-  Hatchery_Instruction_forms_KPI.docx [Download](#)




Upload Drag & Drop Files



Note: files having different name from the original will not be accepted for submission. ?

Company Farm Repository

 CNR - Livorno Private Repository Content

Sel.	Name	Uploaded by	Last Updated (UTC)
<input type="radio"/>	 Hatchery_Individual_Batch_Data_Entry_KPI.xlsx	Giancarlo Panichi	Oct 4, 2018 1:31 PM
<input type="radio"/>	 Hatchery_Aggregated_Batch_Data_Entry KPI CLOSED BATCHES.xlsx	Paolo Rossi	Oct 4, 2018 1:30 PM
<input type="radio"/>	 Hatchery_Aggregated_Batch_Data_Entry_KPI.xlsx	Giancarlo Panichi	Oct 4, 2018 1:32 PM

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RESULTS

The set of KPIs for MMFF sector

The set of KPI developed in task 7.1 and use in PerformFISH project is composed by 55 Key Performances Indicators validated as A-level KPIs and ready to be used.

Most of PerformFISH KPIs are numerical indicators measured and reported by aquaculture companies for certification schemes (e.g. RSPCA, ASC, Global GAP, BAP, Organic), are investigated in scientific literature and are used in best practice guidelines (GAPI,2010), in FAO project on Sustainable Indicators for Mediterranean Aquaculture (InDAM, 2015), in benchmarking system for aquaculture sustainability (GSSI, 205) .

Out of 145 metrics proposed to the PerformFISH consortium in November 2017, a set of 15 KPIs for Hatchery systems, of 5 KPIs for Pre-grow system and of 35 KPIs for Grow out systems have been selected as relevant A-level KPIs by Producer Associations and LTPs (Table 5).

Most of KPI (55 %) are Technical KPIs (TE-KPI) introduced to estimate the technical efficiency of companies, as far losses and diseases, feed efficiency, fish growth, use of chemicals. For grow out production only, a set of 9 Welfare KPIs (WE-KPI) was approved for measuring fish welfare during farming in sea net pens and land-based tanks. A set of 14 Environmental KPIs (E-KPIs) was validated for recording numerical values on the impact of farming practices on marine habitat and biodiversity and the use of land, water, energy (Table 6).

The set of A-level KPIs was approved by the MC and SC and ITEC group of PerformFISH project.

	Hatchery	Pre-grow	Grow-out	Tot
KPI (n)	15	5	35	55
KPI (%)	27	9	64	100

Table 5. Selected relevant A-Level KPIs

	TE-KPI	Ec-KPI	WE-KPI	E-KPIs	Tot
KPI (n)*	35	2	9	14	
KPI (%)	58	3	16	23	100

Table 6. Selected KPIs related to different dimension

*Five KPIs belong to two different dimensions

The list of A-level KPIs, the methodology for data collection, the single form of each KPI, the submission forms prepared (n=2) for recording production data are presented for each production system: Hatchery, Pre-grow and Grow-out.

Sensitive production data

Producers Associations and aquaculture companies are committed with the principle to avoid the discharge of chemicals toxic for wild life and recognised the importance of effectively control the use and the frequency of chemicals, including the potential risks for aquatic environment (flora and fauna) and to human health for microbial resistance. There is a set of KPIs conceived to analyse for the first time the “Dependency on antibiotic and antiparasitic treatments” of the MMFF sector. It is composed of 4 KPIs, based on the number of antibiotic and antiparasitic treatments per year G9, G10 and the amount of antibiotic and antiparasitic active compounds (G11,G12), normalised by ton of biomass. These latter two have been deemed as high level sensitive KPIs and numerical values provided in the submission forms by LTPs and other companies will be kept confidential to Producers Associations (P3,4,5,6,21).

Fish escapees from the industrial facilities is also an issue of great environmental concern for Mediterranean aquaculture, because of potential impact for genetic loss, predation and competition, habitat damage and other impacts on wild life and ecosystems. Knowledge of the extent and causes of escape incidents from sea bass and sea bream net pen facilities is completely lacking (SeaFood Watch, 2014). Producers Associations and aquaculture companies are committed with the principle that farming practices at aquaculture facilities should not pose deleterious effects on wild population and provide data for the estimation of escapee of from sea bass and sea bream batches at industrial facilities. The three E-KPIs measuring, on yearly basis, the number of escapee episodes (G23) and the estimation of the number of escaped (G24) and the impact of farming practices on marine wildlife, as interactions with marine mammals, birds, fish, reptiles (G25) will be also kept confidential to Producers Associations.

For these KPIs (Table 7) the numerical values provided in the submission forms by LTPs and other companies, will be stored in a dedicated repository in the KPI-VRE created for Associations. The policies and the term of use of this VRE for Associations will be defined in the Task.7.2.

All the data collected on these KPIs were recognized by PerformFISH Consortium as high sensitive information and will be thus stored in a special VRE inside D4Science PerformFISH Gateway and kept strictly confidential for Producer Associations, who will decide in agreement with the PerformFISH consortium how to deliver the processed data.

G11	Amount of active compounds - antiparasitic (total & by disease)
G12	Amount of active compounds - antibiotic (total & by disease)
G23	Escapes – Number of episodes
G24	Escapes – Estimated number of escaped fish
G25	Endangered marine mammals, reptiles, fishes and birds lethal incidents

Table 7 List of A-level KPIs manage at Producer Associations level

HATCHERY- List of A- level KPIs

A set of 15 A- level KPI was validated for the analysis of hatchery productivity, biological performances and quality of sea bass and sea bream batches farmed at industrial facilities.

KPI: Hatchery Total Productivity

H1	Weaned fish
H2	Deformed fish
H3	Discarded slow grower fish
H4	Fish produced
H5	Fish produced per FTE employees
H6	Survival estimation
H15	Vaccinated fish by disease

KPI: Fish Deformities

H7	Head deformities
H8	Spinal deformities
H9	Fin deformities
H10	Swim bladder non inflation

KPI: Fish Growth

H11	Average Body Weight (ABW)
H12	Specific Growth Rate (SGR)

KPI: Live Feed Requirements

H13	Artemia requirement
H14	Rotifer requirement

Hatchery – Rationale

Mediterranean aquaculture production of European sea bass and gilthead sea bream is based on the use of produced fish seed at hatchery. Mediterranean hatcheries have reached a high level of standardisation of the controlled reproduction and larval techniques and there has been a good improvement of fry quality and training of skilled personnel for hatchery management and operation in the last decade. The total production of juveniles for the MMFF sector in '000 juveniles is 1'239'594 increased from 2008 of 26% (FEAP, 2016), with Greek as the larger producer (448'000) followed by France (112'220), Italy (101'000) and Spain (77'383). About 63% of juveniles production is represented in PerformFISH project by Partners 3,4,5,6,21 and their Linked Parties.

Most of sea bass and sea bream hatcheries in Mediterranean area are using technology based on closed or semiclosed water recirculating systems, which guarantee a complete independence from external factors related to environmental characteristics of the site. Technological improvements, such as mechanical and biological filters, heaters and sterilizers allow the complete control of the quality of seawater and computerized systems facilitate the control and management of environmental parameters such as oxygen, pH, nitrite and nitrates.

Sea bass and sea bream are winter spawning species and spawning for sea bream started is in November and sea bass in December and last to March, in combination with gilthead sea bream. The production cycle last about four months, that is the time normally required to produce 2 g fry starting from viable larvae, at a water temperature of 18 to 20°C. At present most hatcheries used to **extend the hatchery production period throughout most of the year** by mimic different thermo-photoperiod and manipulating the maturation cycles of breeders. This production strategy has the great advantage to guarantee the availability of fry beyond the natural season and is applied by all hatcheries companies involved as LTPs in PerformFISH (Table 4a). The manipulation and conditioning of broodstock and management of larvae out of natural reproductive period require a good knowledge of biology of species and a careful management of breeders and larvae to avoid larval batches of low quality (Carrillo et al., 1989).

In PerformFISH benchmarking system the collection of production data at hatchery facilities for KPIs is parameterized on three different reproductive periods (natural period, early period and late period). It allows the analysis of the performances of different batches produced out of natural reproductive period and the analysis of larval batch quality, as occurrence and prevalence of deformed and slow grower fish.

Malformations in farmed juveniles are a prime research topic as it has a major impact on fish welfare and on the economical value of the product. Under hatchery conditions, marine fish larvae undergo major functional and morphological changes during the developmental stages and several factors can interfere with ontogenetic development of larvae and affect fry quality. **Morphological malformations** of the skeleton, such as spinal malformation-scoliosis, lordosis, coiled vertebral column, missing or additional fin rays, bending opercle and jaw malformations, are frequently observed in hatchery-reared larvae of sea bass and sea bream (Boglione et al., 2013). There is a wide spectrum of scientific papers and grey literature investigating the type of morphological abnormalities of sea bass and sea bream early life stages, the possible causes and the way of quantifying severity and the impact on the final product's image, fish shape and fish performances (Conceicao, et al. 2018).

The most severe deformities in sea bass and sea bream juveniles affect the spinal column in the form of kyphosis, lordosis or a mix of them. The absence of swimbladder (non inflated) is probably at the origin of lordosis , although this is not, however, the only possible cause. When swimbladder is regularly inflated, the cause of spinal deformity has been found in the high water currents in larval tanks, exceeding 10 cm s⁻¹ during the early weaning phase (Divanach et al., 1997). Several other risk factors, related to elevated temperatures and photoperiod manipulation, environmental conditions and feed composition have been identified in literature, but a clear understanding of the interdependency of genetics, development, rearing environment and feed ingredients is still lacking (Aquaexcel project, D3.2). At present, most of studies on the heritability of malformation traits estimates the sensitivity of fish to the particular hatchery environment as a function of different body weight genotypes (Bardon, 2009; Negrin-Bàez, 2015; Koumondoros, 2018).

Lordosis is one of the most severe deformities developing in reared fish and the evaluation of its effects on fish and economic loss for aquaculture industry has been difficult to establish, since there is no objective way of quantifying its severity and impact. Studies on the effect of lordosis on body shape, analysed by geometric morphometrics, allowed the quantification of lordosis by morphological

landmarks and suggested the possible use of body shape as a index for a precise quality assessment of reared sea bass (Sfakianakis et al., 2006).

At hatchery level, **the monitoring morphological larval quality** starts from the beginning of rearing process and is a way to control standard operating procedures and correct accidental methodological deviations and management operations. Searching for deformities is a routine work during production process at hatchery in order to sort out larvae with non inflated swimbladder and deformed fish at nursery stages. Sorting of malformed fish is usually performed at end of weaning period and during grading procedures on the fish collected to assess size. A careful visual examination on tank population is the most common method to detect abnormal fry at grading and to find deformed fish that are discarded during production process. Analysis of larval morphometry and stereoscopic observations are also used by operators, together with observations of swimming behaviour, which may reveal ontogenetic abnormalities. A major drawback for hatchery industrial production is the long ontogenic period in which a deformity can develop (Koumoundouros, 2010) that leads to the possibility that most of skeletal deformities can become fully develop to be visually and thus identifiable only when fish are over 0.5 g in size. Soft X-rays method are usually used on fingerlings being sold, as a proof of their quality.

At present there is still no a unique method of classification of morphological abnormalities of different ontogenetic stages of sea bass and sea bream and there are not normalised criteria between companies to define whether an individual is deformed or not. There are still large discrepancies in the evaluation of the types of morphological abnormalities, on the prevalence, the estimation of economic losses and for measurement criteria between the companies, and sometime also in the companies themselves (Aquaexcel project, D3.2).

The development of a unique monitoring tool for a precise and accurate estimation of larval quality and a scale of quality for the quantification of the effects of deformities on external morphology of fish (Loy et al., 2000; Sfakianakis et al., 2006) and the correlation of phenotypes of early juveniles and with biological performances of fish at grow out stage are really urgent (Conceicao et al., 2018) (Capitolo 10 Quality descriptors and predictors in farmed marine fish larvae and juveniles and the correlation of morphological quality at different ontogenetic stages at hatchery and the quality of fish is under investigation in the present project (WP2, task 2.2.2, 2.2.) to develop a predictive tool for quality assessment for sea bass and sea bream hatchery juveniles (task 2.2.4).

Considering the lack of a common operational tool for quality assessment of hatchery batches, the benchmarking system for batch deformities included four KPIs (H7, H8, H9, H10) based on the scientific literature (Koumoundouros et al. 1997; Boglione et al. 2001; Koumoundouros 2010; Boglione et al., 2013).

H7. fish head deformities (cranial, jaw and the operculum complex deformities)

H8.spinal column deformities (lordosis, kyphosis and vertebral fusion)

H9. fin deformities

H10. non-inflation of swimbladder

The numerical and operational values of deformities will be recorded at batch and farm level and at different ontogenetic stages, expressed in degree days, to support producers in the comparative analyse of the quality of production batches and the pattern of morphological deformities.

Hatchery is an expensive component of sea bass and sea bream production and aquaculture companies are interested in improving technical efficiency and productivity to make hatchery more profitable. A set of 7 KPIs has been validated to benchmark the productivity of hatchery companies (H1-H6, H15) along the production cycle through the calculation of index of survival, deformed, and slow grower fish, vaccination, and the number of fish produced for Full Time Employees (FTE). Live feeds is also a key component of hatchery production cycle and represent a expensive part of production costs. The early life stages of sea bass and gilthead sea bream are zooplankton-feeders and their successful rearing depends on an adequate supply of high quality live rotifers (*Brachionus plicatilis*) fed on unicellular algae and brine shrimp (*Artemia* spp). The amount of live feed, as rotifer and *Artemia* required to produce juveniles (H11, H12), are deemed as reliable A-Level KPI to analysis the efficiency of hatchery live feed management, at batch and farm level.

Hatchery - Parameterization of production cycle and data collection

Recording uniform KPI is strategic for the correct interpretation of performances among different hatcheries and for benchmarking. Data collection on-farm is an important and unique source of information for comparative analysis and for benchmarking the performances of a given batch at hatchery and between hatcheries. For the purpose of WP7, hatchery production cycle is parameterized as follow:

- **Hatchery/nursery period**, is the initial part of production process in sea bass and sea bream production. It is implemented in land– based establishments and starts from egg to the end of weaning period (Hatchery period) and from the end of weaning to 2400 degree-days (Nursery period). For the purpose of KPI analysis, hatchery and nursery periods are analysed together and the term here used is shortly reported as “Hatchery”. Hatcheries are usually operated using partially or full water recirculating system (RAS) while full open flow through water systems are rarely adopted.
- **Degree days**, a degree day is computed as the integral of a function of time that generally varies with temperature. It is the unit of measure chosen to reduce the risk of misinterpretation of results related to biological performances of larvae and juveniles at different temperature regimes.
- **Stocking period**, is the time when larvae are stocked in hatchery tanks for production cycle. Three different stocking periods are considered to align with routine management procedures used in some hatcheries where the manipulation of thermo and photoperiod is used to extend the reproductive period. Early stocking period is when larvae stocked in hatcheries where obtained from spawning emissions occurring earlier than natural spawning period (July to October); Late stocking period is when egg and larvae stocked in hatcheries where obtained from spawning emissions occurring later than natural spawning period (March to June)

Parameterization for data collection

Data recording for KPIs is performed both at production batch level and at farm level:

- **BATCH level**: data recorded for 1 single production batch, as a group of larvae coming from one or more spawning emissions collected within a 7 days period and managed in one or more hatchery tanks as a single unit until the end of the nursery period

- **FARM level:** data recorded for several production batches coming from multiple spawning emissions in the same stocking period. Data are submitted as aggregated data for the multiple batches in the stocking period.

Collection of production data at hatchery is parameterized according to the three stocking periods in the hatchery:

- **EARLY STOCKING period:** from July to October
- **NATURAL STOCKING period:** from November to February
- **LATE STOCKING period:** from March to June

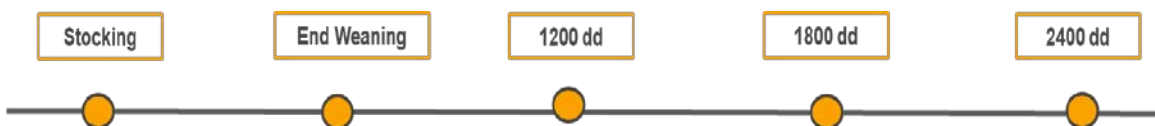
Production data will be recorded at standard intervals, which should be consistent among monitored batches.

At BATCH level data collection is parameterized as follow

- Stocking,
- at 500 degree days for swim bladder inflation,
- at the end of weaning,
- at 1200 degree days,
- at 1800 degree days
- at 2400 degree days,
- at the end of cycle.

At FARM level data recording is parameterized:

- at stocking,
- at the end of weaning,
- and at 2400 degree days



Hatchery – KPIs Forms

ID	H1
KPI	WEANED FISH
DIMENSION	TECHNICAL - TOTAL PRODUCTIVITY

1. DEFINITION

Percentage of weaned fish on number of 1 day post hatching larvae. All the fish that have completed the feeding transition from live food to inert dry artificial diets.

2. INDEX

$$\text{Weaned fish} = \frac{N^{\circ} \text{ of weaned fish}}{N^{\circ} \text{ of larvae at 1 dph}} * 100$$

Unit measure:

%

3. PARAMETERIZATION

Stocking period : Early (JUL-OCT), Natural (NOV-FEB), Late (MAR-JUN).

Population level: Batch, Farm

Frequency of recording: At the end of weaning

Data input in excel form

Batch (B) and Farm (F) level

DATA INPUT		Stocking	500 dd	End of weaning	1200 dd	1800 dd	2400 dd
Larvae at 1 dph	n°	B/F					
Estimated number of weaned fish	n°			B/F			

4. NUMERICAL VALUES OF KPI IN OTHER WORKPACKAGES AND TASKS

WP2	Task name	Leader
Task 2.1.1	Identify Quality Indicators and Predictors of Sea Bream and Sea Bass Larval and Juvenile Quality	UTH
Task 2.1.2	Routine Production System Monitoring	UTH
Task 2.2	Optimisation and Validation of Larval and Juvenile Quality Indicators	CCMAR
WP6		
Task 6.2	Feed – Growth Trial in Different Sea Bass and/or Sea Bream Stocks	HCMR

ID	H2
KPI	DEFORMED FISH
DIMENSION	TECHNICAL - TOTAL PRODUCTIVITY

1. DEFINITION

Percentage of discarded deformed fish on number of 1 day post hatching larvae

2. INDEX

$$\text{Deformed fish} = \frac{\text{N}^\circ \text{ of deformed fish}}{\text{N}^\circ \text{ of larvae at 1 dph}} * 100$$

Unit measure:

%

3. PARAMETERIZATION

Stocking period: Early (JUL-OCT), Natural (NOV-FEB), Late (MAR-JUN).

Population level: Batch, Farm

Frequency of recording: Batch: at 1200, 1800 dd, 2400 dd
Farm: at 2400 dd

Data input in excel form

Batch (B) and Farm (F) level

DATA INPUT		Stocking	500 dd	End of weaning	1200 dd	1800 dd	2400 dd
Larvae at 1 dph	n°	B/F					
Number of fish discarded with head deformities	n°				B ¹	B ¹	B ¹ /F ²
Number of fish discarded with spinal deformities	n°				B ¹	B ¹	B ¹ /F ²
Number of fish discarded with fin deformities	n°				B ¹	B ¹	B ¹ /F ²

4. NUMERICAL VALUES OF KPI IN OTHER WORKPACKAGES AND TASKS

WP2	Task name	Leader
Task 2.1.1	Identify Quality Indicators and Predictors of Sea Bream and Sea Bass Larval and Juvenile Quality	UTH
Task 2.1.2	Routine Production System Monitoring	UTH
Task 2.2	Optimisation and Validation of Larval and Juvenile Quality Indicators	CCMAR
WP6		
Task 6.2	Feed – Growth Trial in Different Sea Bass and/or Sea Bream Stocks	HCMR

Notes:

¹ Estimated number of fish with deformities removed from the batch and discarded during the reference period (e.g. the time interval between 1800 dd and 2400 dd)

² Estimated number of fish with deformities removed from the batches included in the aggregated ID batch and discarded from stocking to 2400 dd

ID	H3
KPI	DISCARDED SLOW GROWER FISH
DIMENSION	TECHNICAL - TOTAL PRODUCTIVITY

1. DEFINITION

Percentage of discarded slow grower fish on number of 1 day post hatching larvae

2. INDEX

$$\text{Discarded slow grower fish} = \frac{N^{\circ} \text{ of discarded fish}}{N^{\circ} \text{ of larvae at 1 dph}} * 100$$

Unit measure

%

3. PARAMETERIZATION

Stocking period: Early (JUL-OCT), Natural (NOV-FEB), Late (MAR-JUN).

Population level: Batch, Farm

Frequency of recording: Batch: at 1200, 1800 dd, 2400 dd
Farm: at 2400 dd

Data input in excel form

Batch (B) and Farm (F) level

DATA INPUT		Stocking	500 dd	End of weaning	1200 dd	1800 dd	2400 dd
Larvae at 1 dph	n°	B/F					
Number of discarded slow grower fish	n°				B ¹	B ¹	B ¹ /F ²

4. NUMERICAL VALUES OF KPI IN OTHER WORKPACKAGES AND TASKS

WP2	Task name	Leader
Task 2.1.1	Identify Quality Indicators and Predictors of Sea Bream and Sea Bass Larval and Juvenile Quality	UTH
Task 2.1.2	Routine Production System Monitoring	UTH
Task 2.2	Optimisation and Validation of Larval and Juvenile Quality Indicators	CCMAR
WP6		
Task 6.2	Feed – Growth Trial in Different Sea Bass and/or Sea Bream Stocks	HCMR

Notes:

¹ Estimated number of discarded slow grower fish during the reference period (e.g. the time interval between 1800 dd and 2400 dd)

² Total number of fish discarded for slow growing during the whole rearing period

ID	H4
KPI	FISH PRODUCED
DIMENSION	TECHNICAL - TOTAL PRODUCTIVITY

1. DEFINITION

Percentage of produced fish, for both internal use or for selling, on number of 1 day post hatching larvae

2. INDEX

$$\text{Fish produced} = \frac{\text{N}^\circ \text{ of fish produced}}{\text{N}^\circ \text{ of larvae at 1 dph}} * 100$$

Unit measure

%

3. PARAMETERIZATION

Stocking period: Early (JUL-OCT), Natural (NOV-FEB), Late (MAR-JUN).

Population level: Batch, Farm

Frequency of recording : Batch: at 2400 dd, end of cycle
Farm: at 2400 dd

Data input in excel form

Batch (B) and Farm (F) level

DATA INPUT		Stocking	500 dd	End of weaning	1200 dd	1800 dd	2400 dd	End of cycle
Larvae at 1 dph	n°	B/F						
Estimated number of fish ¹	n°						B ¹ /F	B ²

4. NUMERICAL VALUES OF KPI IN OTHER WORKPACKAGES AND TASKS

WP2	Task name	Leader
Task 2.1.1	Identify Quality Indicators and Predictors of Sea Bream and Sea Bass Larval and Juvenile Quality	UTH
Task 2.1.2	Routine Production System Monitoring	UTH
Task 2.2	Optimisation and Validation of Larval and Juvenile Quality Indicators	CCMAR
WP6		
Task 6.2	Feed – Growth Trial in Different Sea Bass and/or Sea Bream Stocks	HCMR

Notes:

¹ Total estimated number of fish produced per batches during period. Estimation of fish produced is calculated before fish sorting

² Total number of fish produced at the end of the production cycle (e.g. when the batch is sold or delivered outside the nursery).

ID	H5
KPI	FISH PRODUCED PER FTE EMPLOYEES
DIMENSION	ECONOMIC - TOTAL PRODUCTIVITY

1. DEFINITION

Number of millions fish produced at the end of production cycle per number of employees (FTE - Full Time Equivalents) involved in the production cycle.

2. INDEX

$$\text{Fish produced per FTE employees} = \frac{\text{N}^\circ \text{ of fish produced}}{\text{N}^\circ \text{ of employees (FTE)}}$$

Unit measure

Number fish /FTE employees

3. PARAMETERIZATION

Stocking period: Early (JUL-OCT), Natural (NOV-FEB), Late (MAR-JUN).

Population level: Batch, Farm

Frequency of recording: Batch: 2400 dd
Farm: at 2400 dd

Data input in excel form

Batch (B) and Farm (F) level

DATA INPUT		Stocking	End of weaning	2400 dd
Estimated number of fish	n°			B/F
Number of FTE employees ¹	n°	Hatchery facility data for B/F		

Notes:

¹The concept is used to convert the hours worked by several part-time employees into the hours worked by full-time employees. On an annual basis, an FTE is considered to work the total number of hours worked by a full time employee, therefore each part time employee is accounted as FTE with the following calculation: actual number of working hours in one year of the part time employee (included paid leaves)/annual number of working hours of a full time employee (including paid leaves).

Only employees actually working in the production process should be considered (secretaries or marketing employees have not been included not included). If an employee holds different duties, only the hours spent in the production process will be taken into account.

ID	H6
KPI	SURVIVAL ESTIMATION
DIMENSION	TECHNICAL - TOTAL PRODUCTIVITY

1. DEFINITION

An indicator of the survival at fixed degrees days on number of 1 day post hatching larvae

2. INDEX

$$\text{Survival estimation} = \frac{N^{\circ} \text{ of fish alive}}{N^{\circ} \text{ of larvae at 1dph}} * 100$$

Unit measure

%

3. PARAMETERIZATION

Stocking period: Early (JUL-OCT), Natural (NOV-FEB), Late (MAR-JUN).

Population level: Batch, Farm

Frequency of recording: Batch: at 1200, 1800 dd, 2400 dd
Farm: at 2400 dd

Data input in excel form

Batch (B) and Farm (F) level

DATA INPUT		Stocking	500 dd	End of weaning	1200 dd	1800 dd	2400 dd
Larvae at 1 dph	n°	B/F					
Estimated number of fish ¹	n°				B	B	B/F

¹ Total estimated number of fish produced during the rearing period

4. NUMERICAL VALUES OF KPI IN OTHER WORKPACKAGES AND TASKS

WP2	Task name	Leader
Task 2.1.1	Identify Quality Indicators and Predictors of Sea Bream and Sea Bass Larval and Juvenile Quality	UTH
Task 2.1.2	Routine Production System Monitoring	UTH
Task 2.2	Optimisation and Validation of Larval and Juvenile Quality Indicators	CCMAR
WP3		
Task 3.1	Epidemiology and Health Risk Assessment	UAB
WP6		
Task 6.2	Feed – Growth Trial in Different Sea Bass and/or Sea Bream Stocks	HCMR

ID	H7
KPI	HEAD DEFORMITIES
DIMENSION	TECHNICAL - DEFORMITIES

1. DEFINITION

Percentage of fish with head deformities, operculum included, on number of 1 day post hatching larvae.

2. INDEX

$$\text{Head deformities} = \frac{\text{N}^\circ \text{ of fish with head deformities}}{\text{N}^\circ \text{ of larvae at 1 dph}} * 100$$

Unit measure

%

3. PARAMETERIZATION

Stocking period: Early (JUL-OCT), Natural (NOV-FEB), Late (MAR-JUN).

Population level: Batch, Farm

Frequency of recording: Batch: end of weaning, 2400 dd
Farm: end of weaning at 2400 dd

Data input in excel form

Batch (B) and Farm (F) level

DATA INPUT		Stocking	500 dd	End of weaning	1200 dd	1800 dd	2400 dd
Fish with Head deformities	%			B/F			B/F
Estimated number of fish ¹	n°						B/F

¹ Total estimated number of fish produced during the rearing period

4. NUMERICAL VALUES OF KPI IN OTHER WORKPACKAGES AND TASKS

WP2	Task name	Leader
Task 2.1.1	Identify Quality Indicators and Predictors of Sea Bream and Sea Bass Larval and Juvenile Quality	UTH
Task 2.1.2	Routine Production System Monitoring	UTH
Task 2.2	Optimisation and Validation of Larval and Juvenile Quality Indicators	CCMAR
WP6		
Task 6.2	Feed – Growth Trial in Different Sea Bass and/or Sea Bream Stocks	HCMR

ID	H8
KPI	SPINAL DEFORMITIES
DIMENSION	TECHNICAL - DEFORMITIES

1. DEFINITION

Percentage of fish with spinal deformities on number of 1 day post hatching larvae.

2. INDEX

$$\text{Spinal deformities} = \frac{\text{N}^\circ \text{ of fish with spinal deformities}}{\text{N}^\circ \text{ of larvae at 1dph}} * 100$$

Unit measure

%

3. PARAMETERIZATION

Stocking period: Early (JUL-OCT), Natural (NOV-FEB), Late (MAR-JUN).

Population level: Batch, Farm

Frequency of recording: Batch: end of weaning, at 2400 dd
Farm: end of weaning at 2400 dd

Data input in excel form

Batch (B) and Farm (F) level

DATA INPUT		Stocking	500 dd	End of weaning	1200 dd	1800 dd	2400 dd
Fish with Spinal deformities	%			B/F			B/F
Estimated number of fish ¹	n°						B/F

¹Total estimated number of fish produced during the rearing period

4. NUMERICAL VALUES OF KPI IN OTHER WORKPACKAGES AND TASKS

WP2	Task name	Leader
Task 2.1.1	Identify Quality Indicators and Predictors of Sea Bream and Sea Bass Larval and Juvenile Quality	UTH
Task 2.1.2	Routine Production System Monitoring	UTH
Task 2.2	Optimisation and Validation of Larval and Juvenile Quality Indicators	CCMAR
WP6		
Task 6.2	Feed – Growth Trial in Different Sea Bass and/or Sea Bream Stocks	HCMR

ID	H9
KPI	FIN DEFORMITIES
DIMENSION	TECHNICAL - DEFORMITIES

1. DEFINITION

Percentage of fish with fin deformities on number of 1 day post hatching larvae.

2. INDEX

$$\text{Fin deformities} = \frac{\text{N}^\circ \text{ of fish with fin deformities}}{\text{N}^\circ \text{ of larvae at 1 dph}} * 100$$

Unit measure

%

3. PARAMETERIZATION

Stocking period: Early (JUL-OCT), Natural (NOV-FEB), Late (MAR-JUN).

Population level: Batch, Farm

Frequency of recording: Batch: end of weaning, at 2400 dd
Farm: end of weaning at 2400 dd

Data input in excel form

Batch (B) and Farm (F) level

DATA INPUT		Stocking	500 dd	End of weaning	1200 dd	1800 dd	2400 dd
Fish with Fin deformities	%			B/F			B/F
Estimated number of fish ¹	n°						B/F

¹Total estimated number of fish produced during the rearing period

4. NUMERICAL VALUES OF KPI IN OTHER WORKPACKAGES AND TASKS

WP2	Task name	Leader
Task 2.1.1	Identify Quality Indicators and Predictors of Sea Bream and Sea Bass Larval and Juvenile Quality	UTH
Task 2.1.2	Routine Production System Monitoring	UTH
Task 2.2	Optimisation and Validation of Larval and Juvenile Quality Indicators	CCMAR
WP6		
Task 6.2	Feed – Growth Trial in Different Sea Bass and/or Sea Bream Stocks	HCMR

ID	H10
KPI	SWIM BLADDER NON INFLATION
DIMENSION	TECHNICAL - DEFORMITIES

1. DEFINITION

Percentage of fish with non-inflated swim bladder on number of 1 day post hatching larvae

2. INDEX

$$\text{Swim bladder non inflation} = \frac{N^{\circ} \text{ of fish with non inflated SB}}{N^{\circ} \text{ of larvae at 1dph}} * 100$$

Unit measure

%

3. PARAMETERIZATION

Stocking period: Early (JUL-OCT), Natural (NOV-FEB), Late (MAR-JUN).

Population level: Batch, Farm

Frequency of recording: At 500 dd

Data input in excel form

Batch (B) and Farm (F) level

DATA INPUT		Stocking	500 dd	End of weaning	1200 dd	1800 dd	2400 dd
Percentage of fish with non inflated swim bladder	%		B/F				

4. NUMERICAL VALUES OF KPI IN OTHER WORKPACKAGES AND TASKS

WP2	Task name	Leader
Task 2.1.1	Identify Quality Indicators and Predictors of Sea Bream and Sea Bass Larval and Juvenile Quality	UTH
Task 2.1.2	Routine Production System Monitoring	UTH
Task 2.2	Optimisation and Validation of Larval and Juvenile Quality Indicators	CCMAR
WP6		
Task 6.2	Feed – Growth Trial in Different Sea Bass and/or Sea Bream Stocks	HCMR

ID	H11
KPI	AVERAGE BODY WEIGHT
DIMENSION	TECHNICAL - GROWTH

1. DEFINITION

The wet weight of fish measured as the average body weight at fixed time intervals (given the average density and temperature).

2. INDEX

$$\text{Average body weight} = \frac{\text{Total weight}}{\text{N}^\circ \text{ of fish}}$$

Unit measure

g

3. PARAMETERIZATION

Stocking period: Early (JUL-OCT), Natural (NOV-FEB), Late (MAR-JUN).

Population level: Batch

Frequency of recording: Batch: end of weaning, 1200 dd, 1800 dd, 2400 dd

Data input in excel form

Only at Batch level

DATA INPUT		Stocking	500 dd	End of weaning	1200 dd	1800 dd	2400 dd
Average wet weight of fish	mg			B	B	B	B
Estimated number of fish	n°				B	B	B

4. NUMERICAL VALUES OF KPI IN OTHER WORKPACKAGES AND TASKS

WP2	Task name	Leader
Task 2.1.2	Routine Production System Monitoring	UTH
Task 2.3	Larval and Juvenile Quality Indicators - Optimising Production Traits by Modifying Hatchery Conditions	UoC
Task 2.3.1	Quality Manipulators - Temperature Treatments	UoC
Task 2.3.2	To Estimate the Correlation of Fish Quality Between Different Ontogenetic Stages Maintained Under Different Temperature Regimes	UoC
WP6		
Task 6.2	Feed – Growth Trial in Different Sea Bass and/or Sea Bream Stocks	HCMR

ID	H12
KPI	SPECIFIC GROWTH RATE (SGR)
DIMENSION	TECHNICAL GROWTH

1. DEFINITION

An expression of the daily body weight or growth rate between two sampling dates (given the average density and temperature)

2. INDEX

$$\text{Specific growth rate (SGR)} = \left[\frac{\ln BW_1 - \ln BW_0}{t} \right] * 100$$

BW₀ = Initial body weight; BW₁ = Final body weight; t = time interval (days)

Unit measure

% day⁻¹

3. PARAMETERIZATION

Stocking period: Early (JUL-OCT), Natural (NOV-FEB), Late (MAR-JUN).

Population level: Batch

Frequency of recording: Batch: 1200 dd, 1800 dd, 2400 dd

Data input in excel form

Only at Batch level

DATA INPUT		Stocking	500 dd	End of weaning	1200 dd	1800 dd	2400 dd
Date at the end of period (DD/MM/YY)	date			B	B	B	B
Average wet weight of fish	mg g			B	B	B	B
Estimated number of fish	n°				B	B	B

4. NUMERICAL VALUES OF KPI IN OTHER WORKPACKAGES AND TASKS

WP2	Task name	Leader
Task 2.1.2	Routine Production System Monitoring	UTH
Task 2.3	Larval and Juvenile Quality Indicators - Optimising Production Traits by Modifying Hatchery Conditions	UoC
Task 2.3.1	Quality Manipulators - Temperature Treatments	UoC
Task 2.3.2	To Estimate the Correlation of Fish Quality Between Different Ontogenetic Stages Maintained Under Different Temperature Regimes	UoC
WP6		
Task 6.2	Feed – Growth Trial in Different Sea Bass and/or Sea Bream Stocks	HCMR

ID	H13
KPI	ARTEMIA REQUIREMENT
DIMENSION	TECHNICAL - LIVE FEED REQUIREMENTS

1. DEFINITION

Quantity of Artemia administered during the hatchery phase per million fish produced

2. INDEX

$$\text{Artemia requirement} = \frac{\text{Amount of Artemia used (kg)}}{\text{Millions of fish produced}}$$

Unit measure

Kg of Artemia/million fish

3. PARAMETERIZATION

Stocking period: Early (JUL-OCT), Natural (NOV-FEB), Late (MAR-JUN).

Population level: Batch, Farm

Frequency of recording: Batch: end of weaning

Farm: end of weaning

Data input in excel form

Batch (B) and Farm (F) level

DATA INPUT		Stocking	500 dd	End of weaning	1200 dd	1800 dd	2400 dd
Artemia distribution ¹	kg			B/F			
Estimated number of fish ²	n°						B/F

Notes

¹The amount of Artemia is calculated as the total amount of Artemia cysts (expressed in Kg) used for larval weaning until the end of the weaning period

² Total estimated number of fish produced during the rearing period

ID	H14
KPI	ROTIFER REQUIREMENT
DIMENSION	TECHNICAL - LIVE FEED REQUIREMENTS

1. DEFINITION

Quantity of rotifers (in billions) administered during the hatchery phase per million fish produced

2. INDEX

$$\text{Rotifer requirement} = \frac{\text{Amount of rotifer used (Billions)}}{\text{Millions of fish produced}}$$

Unit measure

Billions rotifer/million fish

3. PARAMETERIZATION

Stocking period: Early (JUL-OCT), Natural (NOV-FEB), Late (MAR-JUN).

Population level: Batch, Farm

Frequency of recording: Batch: end of weaning

Farm: end of weaning

Data input in excel form

Batch (B) and Farm (F) level

DATA INPUT		Stocking	500 dd	End of weaning	1200 dd	1800 dd	2400 dd
Rotifers distribution ¹	billions			B/F			
Estimated number of fish	n°						B/F

Notes

¹Total number of Rotifers (billions) used to wean larval batches until the end of the weaning period

ID	H15
KPI	VACCINATED FISH BY DISEASE
DIMENSION	TECHNICAL - TOTAL PRODUCTIVITY

1. DEFINITION

Percentage of vaccinated fish by disease on total number of produced fish.

2. INDEX

$$\text{Vaccinated fish by disease} = \frac{\text{N}^\circ \text{ of vaccinated fish (e.g. } P. damselae)}{\text{N}^\circ \text{ of produced fish}} \times 100$$

Unit measure

%

3. PARAMETERIZATION

Stocking period: Early (JUL-OCT), Natural (NOV-FEB), Late (MAR-JUN).

Population level: Batch, Farm

Frequency of recording: Batch: 2400 dd

Farm: 2400 dd

Data input in excel form

Batch (B) and Farm (F) level

DATA INPUT		Stocking	500 dd	End of weaning	1200 dd	1800 dd	2400 dd
Number of fish vaccinated against <i>P. damselae</i>	n°						B/F
Number of fish vaccinated against <i>V. anguillarum</i>	n°						B/F
Number of fish vaccinated against Betanodavirus	n°						B/F
Estimated number of fish	n°						B/F

4. NUMERICAL VALUES OF KPI IN OTHER WORKPACKAGES AND TASKS

WP3	Task name	Leader
Task 3.1	Epidemiology and Health Risk Assessment.	UAB
WP6		
Task 6.1	Integrated Health Management	AQUARK CETGA

PRE – GROW - List of A- level KPIs

KPI: Pre-grow Total Productivity

P1	Deformed fish
P2	Discarded slow grower fish
P3	Mortalities - total

KPI: Fish Growth

P4	Specific Growth Rate (SGR)
----	----------------------------

KPI: Feed Efficiency

P5	Feed Conversion Ratio (FCR)
----	-----------------------------

Pre-grow - Rationale

This period represents the part of the production process from hatchery/nursery up to the transfer to grow out systems (stocking size >2 – final size <20g). Thus, this period is strictly linked with the previous hatchery period, it may be considered as a “finishing process” where the quality of the juveniles can be improved through additional grading and selection (removal) of deformities and slow grower fish.

This period may be skipped stocking fish >2g directly in the grow out facilities; in this case the data recording and KPIs calculation will be performed as per the grow out period.

This phase is usually implemented in land-based systems using tanks/raceways, equipped with open flow through or recirculated water systems, and rarely in small, dedicated cages.

A set of 5 KPIs, already validated for hatchery period, were selected for benchmarking the total productivity, growth and feed efficiency over pre-grow period. These refer to the quality and health of juveniles, growth and feed conversion.

In this phase the quality of feed and feeding strategies as well as good management practices play a fundamental role in ensuring robust and healthy fish for the grow out phase.

Pre-grow - Parameterization of production cycle and data collection

Recording uniform KPIs is strategic for the correct interpretation of performances among different hatcheries and for benchmarking.

Parameterization for data collection

Data recording for KPIs is performed only at production batch level:

- **BATCH level:** data recorded for 1 single production batch, as a group ideally, homogeneous for size and source of fish, produced/imported from a hatchery and transferred to Pre-grow sector within 10days and managed in one or more rearing tanks as a single unit, until the end of the Pre-grow period. (table 2).

Recording of production data for KPIs is firstly parameterized according to the stocking periods. We have identified 3 stocking periods:

- EARLY stocking period: from November to February
- NATURAL stocking period: from March to June
- LATE stocking period: from July to October

Production data recorded at standard intervals, which should be consistent among monitored batches

Data collection is parameterized as follow:

- Stocking
- End of pre-grow cycle



Pre-grow – KPIs Forms

ID	P1
KPI	DEFORMED FISH
DIMENSION	TECHNICAL - TOTAL PRODUCTIVITY

1. DEFINITION

Percentage of discarded deformed fish on number of stocked fish

2. INDEX

$$\text{Deformed fish} = \frac{N^{\circ} \text{ of deformed fish}}{N^{\circ} \text{ of stocked fish}} * 100$$

Unit measure

%

3. PARAMETERIZATION

Stocking period Early (NOV-FEB), Natural (MAR-JUN), Late (JUL-OCT)

Population level Batch

Frequency of recording End of cycle

Data input in excel form

Batch level

DATA INPUT IN VRE		Stocking	End of cycle
Fish stocked	n°	✓	
Discarded deformed fish	n°		✓

4. NUMERICAL VALUES OF KPI IN OTHER PERFORMFISH TASKS

WP2	Task name	Leader
Task 2.2	Optimisation and Validation of Larval and Juvenile Quality Indicators	CCMAR
Task 2.3	Larval and Juvenile Quality Indicators – Optimising Production Traits by Modifyng Hatchery Conditions	UoC
WP6		
Task 6.2	Feed – Growth Trial in Different Sea Bass and/or Sea Bream Stocks	HCMR

ID	P2
KPI	DISCARDED SLOW GROWER FISH
DIMENSION	TECHNICAL - TOTAL PRODUCTIVITY

1. DEFINITION

Percentage of discarded slow grower fish on number of stocked fish

2. INDEX

$$\text{Discarded slow grower fish} = \frac{N^{\circ} \text{ of discarded fish}}{N^{\circ} \text{ of stocked fish}} * 100$$

Unit measure

%

3. PARAMETERIZATION

Stocking period Early (NOV-FEB), Natural (MAR-JUN), Late (JUL-OCT)

Population level Batch

Frequency of recording End of cycle

Data input in excel form

Batch level

DATA INPUT IN VRE		Stocking	End of cycle
Fish stocked	n°	✓	
Discarded slow grower fish	n°		✓

4. NUMERICAL VALUES OF KPI IN OTHER PERFORMFISH TASKS

WP2	Task name	Leader
Task 2.2	Optimisation and Validation of Larval and Juvenile Quality Indicators	CCMAR
Task 2.3	Larval and Juvenile Quality Indicators – Optimising Production Traits by Modifyng Hatchery Conditions	UoC
WP6		
Task 6.2	Feed – Growth Trial in Different Sea Bass and/or Sea Bream Stocks	HCMR

ID	P3
KPI	MORTALITIES - TOTAL
DIMENSION	TECHNICAL - TOTAL PRODUCTIVITY

1. DEFINITION

Percentage of dead fish due to all possible causes: diseases, management, environmental, nutrition, stress, accidents, unknown, etc.

2. INDEX

$$\text{Mortalities (Total)} = \frac{\text{N}^\circ \text{ of collected dead fish}}{\text{N}^\circ \text{ of stocked fish}} * 100$$

Unit measure

%

3. PARAMETERIZATION

Stocking period Early (NOV-FEB), Natural (MAR-JUN), Late (JUL-OCT)

Population level Batch

Frequency of recording End of cycle

Data input in excel form

Batch level

DATA INPUT IN VRE		Stocking	End of cycle
Fish stocked	n°	✓	
Dead fish	n°		✓

4. NUMERICAL VALUES OF KPI IN OTHER PERFORMFISH TASKS

WP3	Task name	Leader
Task 3.1	Epidemiology and Health Risk Assessment	UAB
Task 3.4	Medicines, Biocided and Bioactive compounds	HCMR
Task 3.5.2	Welfare Evaluation	ISPRA
WP6		
Task 6.1	Integrated Health Management	HCMR
Task 6.2	Feed – Growth Trial in Different Sea Bass and/or Sea Bream Stocks	HCMR

ID	P4
KPI	SPECIFIC GROWTH RATE (SGR)
DIMENSION	TECHNICAL - GROWTH

1. DEFINITION

Daily body weight or growth rate between two sampling dates

2. INDEX

$$\text{Specific Growth Rate (SGR)} = \left[\frac{\ln BW_1 - \ln BW_0}{t} \right] * 100$$

BW₀ = Initial body weight; BW₁ = Final body weight; t = time interval (days)

Unit measure

% day⁻¹

3. PARAMETERIZATION

Stocking period Early (NOV-FEB), Natural (MAR-JUN), Late (JUL-OCT)

Population level Batch

Frequency of recording End of cycle

Data input in excel form

Batch level

DATA INPUT IN VRE		Stocking	End of cycle
Date of stocking (DD/MM/YY)	date	✓	
ABW (end of pre-grow cycle)	g		✓
Date of the end of pre-grow cycle (DD/MM/YY)	date		✓
ABW at stocking	g	✓	

4. NUMERICAL VALUES OF KPI IN OTHER PERFORMFISH TASKS

WP4	Task name	Leader
Task 4.1.2	Determination of Recommended Levels of Specific Nutrients for Sea Bream and Sea Bass to Maximise Growth Performance and Feed Utilisation	ULPGC
Task 4.2.2	Novel Cost Effective Lipid Sources (omega yeasts, microalgae, marine microorganisms, camelina seeds, oils, etc.)	ULPGC
WP6		
Task 6.1	Integrated Health Management	HCMR
Task 6.2	Feed – Growth Trial in Different Sea Bass and/or Sea Bream Stocks	HCMR

ID	P5
KPI	FEED CONVERSION RATIO (FCR)
DIMENSION	TECHNICAL - FEED EFFICIENCY

1. DEFINITION

The ratio between the dry weight of feed and the weight of yield gain. The amount of feed used by lost animals (dead and escaped) is counted in the equation

2. INDEX

$$\text{Feed Conversion Ratio (FCR)} = \frac{\text{Feed delivered } (t_1 - t_0)}{(\text{Biomass}_1 - \text{Biomass}_0)}$$

Feed delivered(t₁-t₀)= Feed delivered during time interval

Biomass₀=Initial biomass; Biomass₁=Final biomass

Unit measure

Numerical index without unit

3. PARAMETERIZATION

Stocking period Early (NOV-FEB), Natural (MAR-JUN), Late (JUL-OCT)

Population level Batch

Frequency of recording End of cycle

Data input in excel form

Batch level

DATA INPUT IN VRE		Stocking	End of cycle
Fish stocked	n°	✓	
ABW at stocking	g	✓	
Dry feed amount	kg		✓
Number of harvested fish	n°		✓
ABW (end of pre-grow cycle)	g		✓

4. NUMERICAL VALUES OF KPI IN OTHER PERFORMFISH TASKS

WP4	Task name	Leader
Task 4.1.2	Determination of Recommended Levels of Specific Nutrients for Sea Bream and Sea Bass to Maximise Growth Performance and Feed Utilisation	ULPGC
Task 4.2.2	Novel Cost Effective Lipid Sources (omega yeasts, microalgae, marine microorganisms, camelina seeds, oils, etc.)	ULPGC
WP6		
Task 6.1	Integrated Health Management	HCMR
Task 6.2	Feed – Growth Trial in Different Sea Bass and/or Sea Bream Stocks	HCMR

GROW OUT- List of A- level KPIs

A set of 35 KPI has been validated by PerformFISH consortium for the analysis and for or benchmarking of grow out systems. The set of KPIs include 15 TE-KPIs, 2 Ec-KPIs, 9 WE-KPIs and 14 E-KPIs and is build to benchmarking: Fish Losses, Dependency on Treatment; Fish Growth, Feed Efficiency, Productivity, Fish Welfare and Environmental performances.

KPI: Fish Losses

G1	Mortalities - total
G2	Mortalities – by disease
G4	Mortalities first 10 days after transport and stocking
G5	Unaccounted losses
G6	Total losses
G7	Discarded fish at slaughter

KPI: Dependency on treatments

G9	Number of antiparasitic treatments (total & by disease)
G10	Number of antibiotic treatments (total & by disease)
G11	Amount of active compounds - antiparasitic (total & by disease)
G12	Amount of active compounds - antibiotic (total & by disease)

KPI: Fish Growth

G13	Specific Growth Rate (SGR)
G14	Grams per day (GPD)
G15	Thermal Growth Coefficient (TGC)

KPI: Feed Efficiency

G16	Feed Conversion Ratio (FCR)
G17	Biological Feed Conversion Ratio (FCR _{BIO})

KPI: Productivity

G20	Biomass produced per number of FTE employees
G21	Biomass produced per volumes of sea water used

KPI: Fish Welfare

G1	Mortalities - total
G3	Mortalities first 3 days after transport and stocking
G4	Mortalities first 10 days after transport and stocking
G8	Vaccinated fish – by disease
G9	Number of antiparasitic treatments (total & by disease)
G10	Number of antibiotic treatments (total & by disease)
G18	Feed Intake (FI)
G19	Stocking density
G22	Oxygen depletion persistence days

KPI: Environmental

Preservation of biodiversity and habitats KPIs

G22	Oxygen depletion persistence days
G23	Escapes – Number of episodes
G24	Escapes – Estimated number of escaped fish (confidential ISAB)
G25	Endangered marine mammals, reptiles, fishes and birds lethal incidents (confidential ISAB)
G26	Phosphorous accumulated in sediment
G27	Nitrogen accumulated in sediment

KPI: Environmental performances

Use of resources

G28	Marine space use for farming
G29	Land use
G30	Freshwater use
G31	Energy used
G32	Fuel (Diesel) used for transport
G33	Fuel (Diesel) used for other uses
G34	Total emission of CO ₂
G35	Use of renewable energy

Grow –out – Parameterization of production cycle and data collection

For grow-out systems, which differ in technologies and are located in marine sites and on land, the collection of uniform KPI is strategic for the correct interpretation of data set and for the development of a valid benchmarking tool. For the purpose of WP7, grow-out is parameterized as follow:

Grow-out is defined as the part of the production process from juveniles (>2g) up to the harvest. It is implemented either in the sea with the use of nets and floating devices forming floating cages (net pen facilities) or in land-based tanks (land-tanks) equipped with flow through water systems or partially/totally recirculated water system.

Farming area is a marine area where two or more aquaculture grow out farms are located and managed with the same aquaculture practices (by the same company or by different companies)

Farm is an grow-out aquaculture site inside the farming area, characterised by similar environmental conditions (e.g. temperature, currents, etc...), where group(s) of rearing units are located and managed by the same company

Rearing unit is a single structure holding the fish (e.g. a net pen, a tank or a pond).

Stocking period is the quarter of the year when a batch is stocked: 1st Quarter = Jan – Mar; 2nd Quarter = Apr – Jun; 3rd Quarter = Jul – Sep; 4th Quarter = Oct – Dec

Geographic areas are defined as marine areas across the Mediterranean sea where aquaculture facilities are located and characterized by different seawater temperature profiles. Data are derived from Copernicus time series data of seawater temperature in Mediterranean area and are used to identified different T-areas and allocate aquaculture farm.

Identification of geographic areas

Aquaculture performances of open aquaculture systems (e.g. net pen farms) are expected to have a significant variations depending on the geographic location of the facilities and, therefore, on the actual temperature profile of water in the site.

In order to have a proper application of the benchmarking system, where technical efficiency is compared among farms through the calculation of specific KPIs, data on Sea Surface Temperature (SST) have been collected and analysed to allocate each farm participating to the KPI exercise to different zones which are homogenous for their temperature profiles.

Time series of Sea Surface Temperatures in °C, collected from the Sentinel satellite network on a period of ten years (2006-2015) have been collected from the Copernicus Marine Environment Monitoring Service (CMEMS). Resolution of the satellite dataset is 0.0625 degrees (around 6.5 Km on the earth surface), which is enough considering that values of SST can be considered homogeneous at this resolution scale.. The average seasonal SST and the average yearly SST have been calculated from the time series dataset of the SST recorded over the period 2006-2015, obtaining a georeferred Mediterranean SST maps that will be used in a Geographic Information System (GIS) environment to identify different areas according to temperature and to allocate each aquaculture farm to one of this area.

Therefore, production data provided by companies for the calculation of each KPIs will be analysed and compared by geographic area, facilitating the development of a benchmarking system per area and ensuring that the differences in performance due to different water temperatures will be minimized.

At the date of this report, information on the exact location of the farms participating to the KPI exercise is still due by the producer associations of France and Spain. Once the exact locations of farms (Latitude and longitude) will be provided, farm locations will be added to the GIS database and the definition of the three zones homogeneous for temperature and, possibly, number of farms will be finalized.

In Figure 6 Mediterranean map showing the average yearly temperature over the ten year period: each colour represents 1°C SST interval.

In Figure 7 Mediterranean maps showing the average seasonal temperature over the ten year period: each colour represents 1°C SST interval.

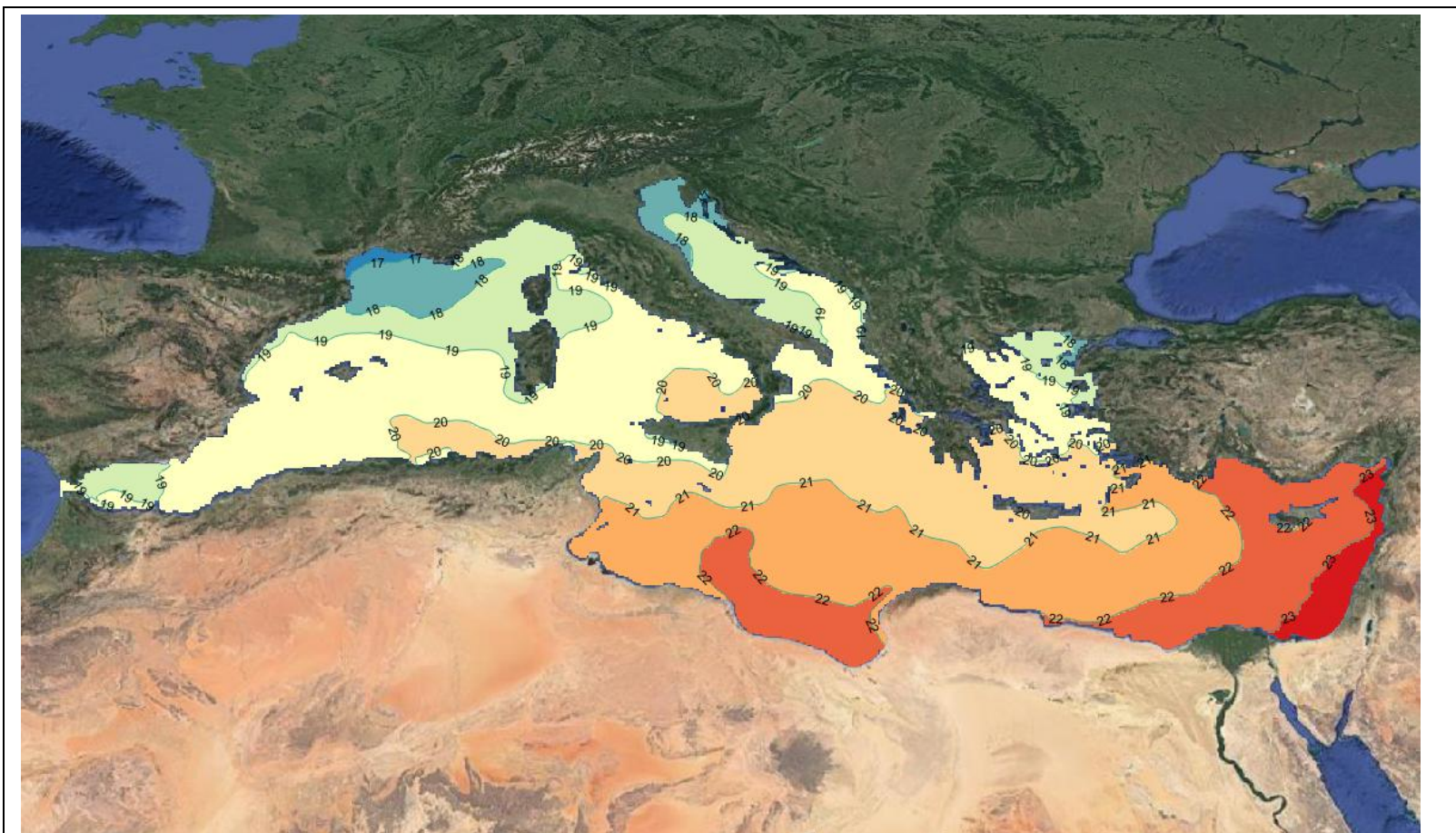
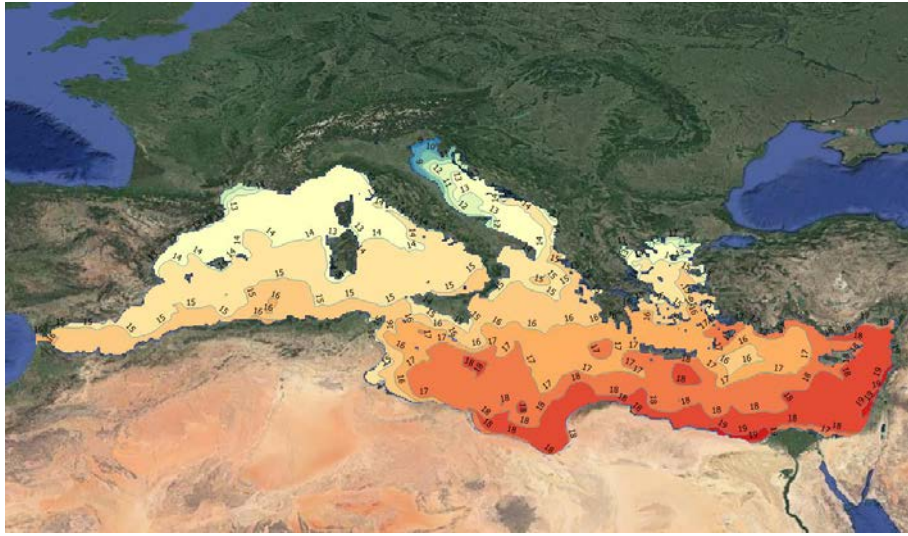
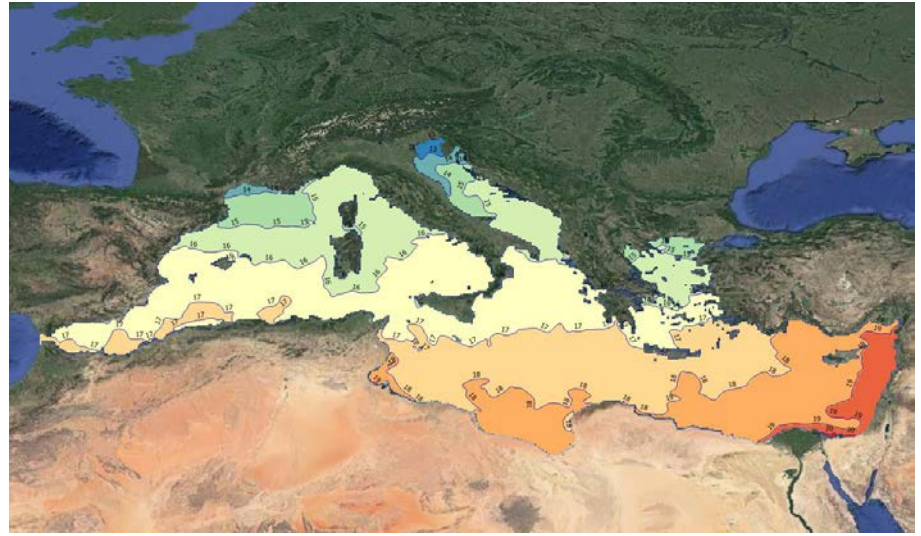


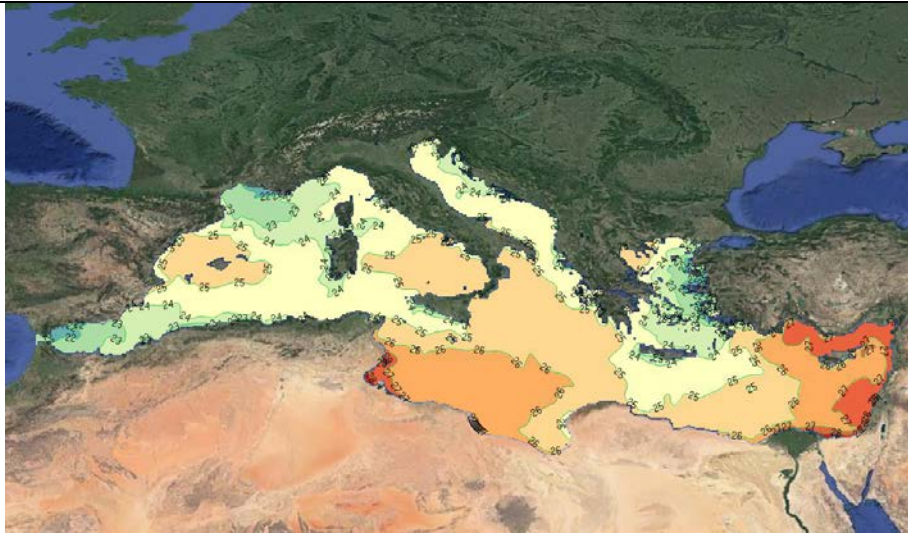
Figure 6. Yearly SST means over the period 2006-2015, 1°C intervals



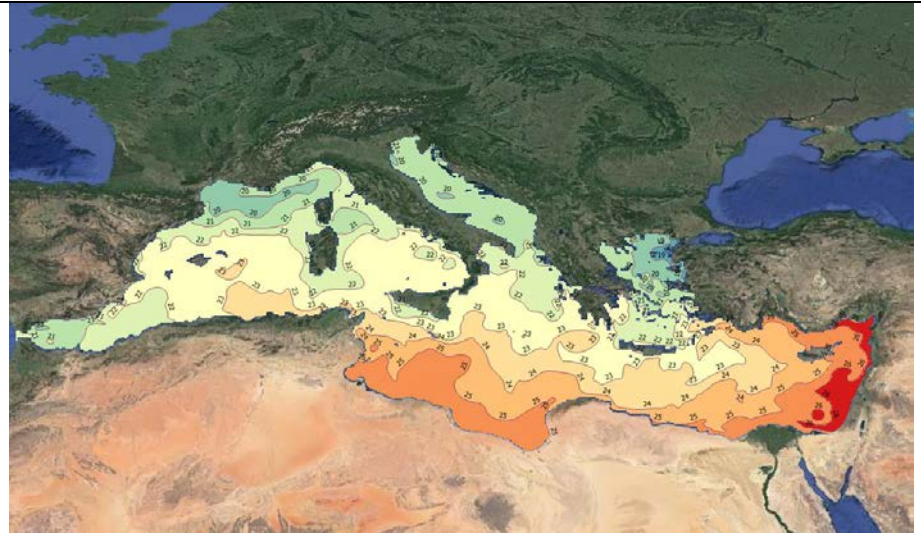
Winter



Spring



Summer



Autumn

Figure 7 Seasonal SST means over the period 2006-2015, 1°C intervals

Parameterization of data collection at grow-out facilities

Data recording for KPIs is performed both at production batch level and at farm level:

- **BATCH level:** data recorded for 1 single production batch is a group of fish, ideally homogeneous for size and source, stocked in grow out within 2 weeks and managed in one or more rearing units until the end of the grow out cycle and harvest. The number of batches to monitor for KPIs should be representative of the farm production.
- **FARM level:** data recorded for several production batches (*aggregated batches*) as groups of individual batch reared in multiple rearing units which data are submitted aggregated, according to the stocking period (1st - 4th Quarter).

The collection of production data at grow-out system is for set numerical operational values for the analysis and calculation of **Technical KPIs** belonging to the following categories: Fish Losses, Fish Growth, Feed Efficiency and **Welfare KPIs**. The collection of production data is parameterized according to the date of fish stocking (Quarters) and the size of fish (average body weight).

- 1st Quarter = Jan – Mar;
- 2nd Quarter = Apr – Jun;
- 3rd Quarter = Jul – Sep;
- 4th Quarter = Oct – Dec

Reference period is a time period in the quarter between two established targets (in this case conventional sizes of fish), e.g. the time interval during which the batch has grown from 50 grams to 150 grams average body weight (AVB)BW.

At BATCH level, production data collection is parameterized at standard intervals, which should be consistent among monitored batches, and defined on the basis of the average body size of fish.

- At stocking
- From stocking to the date when fish reach 50g average body weight (+ 5%)
- From 51 to 150g (+ 5%)
- From 151 to 250g (+ 5%)
- From 401 to 800g (for farms that sell large portion fish)
- At harvested batches (whenever harvest is performed)



At FARM level production data collection is parameterized at the following interval:

- At stocking
- From stocking to the date when fish reach 150g average body weight (+ 5%)
- From 151 to 400g (+ 5%)
- From 401 to 800 (+ 5%) (for farms that sell large portion fish)
- At harvested batches (whenever harvest is performed)

Data collection for Environmental KPIs (G22-G35) is organised on yearly basis

Data collection for the “Dependency of treatments” KPIs is organised on yearly basis

Standard Operating Procedures for data collection at growth out system are synthesised in section XX of the DL 7.1 and the list of data input is reported in the Annex 2.

The Manual for Standard Operating Procedures – *Collection of production data at industrial facilities for Key Performances Indicators* – available at the PerformFISH Gateway, has been prepared to facilitate farmers and managers to record uniform KPIs, providing information on how perform data collection and how to provide production data at the appropriate standard intervals using the Submission Form.

Grow out- Losses – Rationale

#ID	Losses KPIs – A Level
G1	Mortalities – total
G2	Mortalities - by disease
G4	Mortalities first 10 days after transport and stocking
G5	Unaccounted losses
G6	Total losses
G7	Discharged fish at slaughter

Losses represent an important component of production costs for MMFF sector.

Presently the majority of sea bass and sea bream managers use sophisticated IT software, as a tool for production control and for monitoring health data, fish losses, specific mortality and fish movements. These data stored in on-farm database are available for investigating the pattern of losses across the production cycle and the factors that contribute to the variation in losses. The record of mortalities is indeed essential for the identification of factors that contribute to the variations in mortality rate and for benchmarking the expected mortality across time (Soares et al., 2013). Mortality records held in farm databases are, however, never used for comparing and benchmarking losses among different aquaculture companies.

This set of six T- Health KPIs was constructed for benchmarking losses in sea bass and sea bream batches reared in grow out production systems, in net pen and land based tanks.

The T- Health KPIs measured the total mortality, as the counted losses due to all possible causes, the mortality by specific disease (virus, parasite, bacteria) and the unaccounted losses, as fish not found and not counted due to cannibalism, predators, escapes, or other reasons. From the point of view of the productivity, also the discharged fish at slaughter (e.g. damaged, deformed, emaciated, etc.) are considered in the count of losses. All above losses contribute to the KPI for total losses.

Losses caused by various diseases represent a substantial proportion of economic loss in sea bass and sea bream industry and also represent a key constraints to Mediterranean aquaculture development (FAO, 2007; FAO, Strategy 2018). Diseases also reduce fish welfare, impair growth, increase food conversion rate and increase production costs due to prevention (e.g. vaccination, biosecurity measures) and treatments.

Data on diseases affecting farmed sea bass and sea bream are mainly available on scientific and grey literature and observations/communications of experts. There are not extensive official reports available on the occurrence of diseases for MMFF sector, neither at country level or at sector level as in case of salmon industry (e.g. Norway, USA). This is basically because none of the diseases affecting sea bass and sea bream are included in the listed diseases of Directive 2006/88/EC (Annex IV) and only a little information is available from national surveillance programmes. In 2016 and 2017, fish health

problems have been reported to be primarily related to VNN/VER, Tenacibaculosis, *Vibrio harveyi*, *Lernanthropus kroyeri*, Microcotylosis, *Sparicotyle* sp. and Rash syndrome (EURL Report, 2016; 2017).

The occurrence of diseases in farmed sea bass and sea bream changes among EU Member States, with the exception of VNN which causes serious economic impact due to mortality and growth reduction in almost all aquaculture companies in Mediterranean basin.

Looking at bacterial disease, Vibriosis still play an important role in sea bass, with *Vibrio harveyi* recognized as an emerging issue. Photobacteriosis represents still a major problem in both species, due to the short protection of vaccination and efficacy of antibiotic treatments in symptomatic/anorexic fish. Regarding parasites, gill flukes (e.g. *Sparicotyle chrysophrii*) emerge as an important health problem in sea bream due to difficulties in antiparasitic treatments as well as crustaceans infestations (e.g. Isopoda) in sea bass. Skin diseases as petechial rash/red spot disease represents an emerging issue, especially in sea bream (Vendramin et al., 2016; Schmidt et al., 2018).

The “List of Concern” of disease agents considered in PerformFISH has been defined by scientific partners (P12, P25), with the support of ITEC and according to information provided by LTPs during meeting and training workshop (Table 8).

Benchmarking losses and mortalities using KPIs will provide a different insight on the impact of diseases, allowing companies to better address health and management issues. Results will further contribute to harmonize disease control and prevention strategies in MMFF sector and will improve the knowledge for epidemiological studies and risk analysis, consistently with the new animal health Regulation 2016/429/EU.

List of major disease agents selected in PerformFISH		
Viruses	Sea bream	Sea bass
Betanodavirus (VNN)		✓
Bacteria		
<i>Photobacterium damsela piscicida</i>	✓	✓
<i>Tenacibaculum maritimum</i>	✓	✓
<i>Vibrio anguillarum</i>		✓
Other Vibrionaceae (e.g. <i>Vibrio harveyi</i>)		✓
Parasites		
Monogenea (<i>Sparicotyle chrysophrii</i>)	✓	
Myxozoa (<i>Enteromyxum leei</i>)	✓	
Microsporidia	✓	
Isopod crustaceans (<i>Ceratothoa oestroides</i>)		✓
Copepod crustaceans (<i>Lernanthropus kroyeri</i>)		✓
Other		
Petechial rash disease/red spot syndrome	✓	

Table 8. List of major disease agents selected in PerformFISH

Other diseases of interest:

Sea bream: Lymphocystis, Epitheliocystis, Enteritis, Winter syndrome.

Sea bass: Aeromonas infections, Streptococcosis, Rickettsiosis, Red spot syndrome, Infestation by other copepod crustaceans (Caligus) and Myxosporidia.

Grow out- Losses – KPIs Forms

ID	G1
KPI	MORTALITIES - TOTAL
DIMENSION	TECHNICAL & WELFARE - LOSSES

1. DEFINITION

Percentage of dead fish due to all possible causes: diseases, management, environmental, nutrition, stress, accidents, unknown, etc.

2. INDEX

$$\text{Mortalities (Total)} = \frac{\text{N}^\circ \text{ of collected dead fish}}{\text{N}^\circ \text{ of stocked fish}} * 100$$

Unit measure

%

3. PARAMETERIZATION

Stocking period : 1st Quarter (JAN – MAR), 2nd Quarter (APR – JUN),
3rd Quarter (JUL – SEP), 4th Quarter (OCT- DEC)

Population level: Batch, Farm, Area

Frequency of recording: Batch: 50g, 150g, 250g, 400g, 800g/harvested batches
Farm and Area: 150g, 250g, 400g, 800g/harvested batches

Data input in excel form

Batch (B) and Farm (F) level

DATA INPUT		Stocking	50g	150g	250g	400g	800g	Harvest ^a
Total mortality (n of dead fish)	n°	B/F	B/F	B/F	B/F	B/F	B/F	B/F
Number of stocked fish	n°	B/F						

^a whenever harvest is performed

4. NUMERICAL VALUES OF KPI IN OTHER WORKPACKAGES AND TASKS

WP3	Task name	Leader
Task 3.1	Epidemiology and Health Risk Assessment	UAB
Task 3.4	Medicines, Biocided and Bioactive compounds	HCMR
Task 3.5.2	Welfare Evaluation	ISPRA
WP4		
Task 4.2	Development of Sustainable and Cost-Effective Feeds	ULPGC; HCMR
Task 4.3	Conditioning of Farmed Species to Novel Feeds to Improve Feed Utilisation, Growth and Fish Health	ULPGC
WP6		
Task 6.1	Integrated Health Management	HCMR
Task 6.2	Feed – Growth Trial in Different Sea Bass and/or Sea Bream Stocks	HCMR

Notes

- Quantification of mortality can be done either counting or assessing the number of dead fish. The quantity of mortality used in the KPI calculation shall be consistent with the quantification of the batch(s) mortality as reported in the farm register.

➤ Reference to:

- Certification Schemes: RSPCA; ASC; Global G.A.P.; Organic
- Welfare Index models: SWIM (Atlantic salmon);
- Best practices and Guidelines: FISHWELL HANDBOOK (Atlantic salmon).

ID	G2
KPI	MORTALITIES – BY DISEASE
DIMENSION	TECHNICAL - LOSSES

1. DEFINITION

Percentage of all losses due to diseases. Total mortalities attributed to diseases have to be counted as i) pathogens as identified by ITEC ii) combination of diseases and iii) other diseases.

2. INDEX

$$\text{Mortalities (by disease)} = \frac{\text{N}^\circ \text{ of dead fish by disease}}{\text{N}^\circ \text{ of stocked fish}} * 100$$

Unit measure

%

3. PARAMETERIZATION

Stocking period: 1st Quarter (JAN – MAR), 2nd Quarter (APR – JUN),
3rd Quarter (JUL – SEP), 4th Quarter (OCT- DEC)

Population level: Batch, Farm, Area

Frequency of recording: Batch: 50g, 150g, 250gr, 400g, 800/harvested batches
Farm and Area: 150g, 250gr, 400g, 800/harvested batches

Data input in excel form

Batch (B) and Farm (F) level

DATA INPUT		Stocking	50g	150g	250g	400g	800g	Harvest ^a
Number of stocked fish	n°	B/F						
Number of dead fish (Type of disease 1)	n°		B/F	B/F	B/F	B/F	B/F	B/F
Number of dead fish (Type of disease 2)	n°		B/F	B/F	B/F	B/F	B/F	B/F
Number of dead fish (Type of disease 3)	n°		B/F	B/F	B/F	B/F	B/F	B/F

^a whenever harvest is performed

4. NUMERICAL VALUES OF KPI IN OTHER WORKPACKAGES AND TASKS

WP3	Task name	Leader
Task 3.1	Epidemiology and Health Risk Assessment	UAB
Task 3.3	Vaccines and Vaccination	AQUAXPRS
Task 3.4	Medicines: Current Use	HCMR
Task 3.5.3	Welfare Evaluation	AQUAXPRS
WP4		
Task 4.3	Conditioning of Farmed Species to Novel Feeds to Improve Feed Utilisation, Growth and Fish Health	ULPGC
WP6		
Task 6.1	Integrated Health Management	HCMR
Task 6.2	Feed – Growth Trial in Different Sea Bass and/or Sea Bream Stocks	HCMR

Notes:

In case that more than one pathogen is identified simultaneously on a batch of fish, the cause of mortality should be attributed to only one pathogen, the most important based on the farm veterinarian expert judgment

ID	G4
KPI	MORTALITIES FIRST 10 DAYS AFTER TRANSPORT AND STOCKING
DIMENSION	TECHNICAL & WELFARE - LOSSES

1. DEFINITION

It refers to mortalities after transport from nursery to farm due to handling stress and stocking occurring within the first 10 days

2. INDEX

$$\text{Mortalities first 10 days after transport and stocking} = \frac{\text{N}^\circ \text{ of collected dead fish at day 10}}{\text{N}^\circ \text{ of stocked fish}} * 100$$

Unit measure

%

3. PARAMETERIZATION

Stocking period: 1st Quarter (JAN – MAR), 2nd Quarter (APR – JUN),
3rd Quarter (JUL – SEP), 4th Quarter (OCT- DEC)

Population level: Batch, Farm, Area

Frequency of recording: Batch: at day 10
Farm and Area: at day 10

Data input in excel form

Batch (B) and Farm (F) level

DATA INPUT		Stocking	50g	150g	250g	400g	800g	Harvest
Number of stocked fish	n°	B/F						
Number of dead fish at day 10 from stocking	n°	B/F						

4. NUMERICAL VALUES OF KPI IN OTHER WORKPACKAGES AND TASKS

WP 3	Task name	Leader
Task 3.5.3	Welfare evaluation	ISPRA

Notes

Reference to:

- Certification Schemes: RSPCA;
- Best practices and Guidelines: FISHWELL HANDBOOK (Atlantic salmon)

ID	G5
KPI	UNACCOUNTED LOSSES
DIMENSION	TECHNICAL - LOSSES

1. DEFINITION

The percentage of fish not found and not counted as known mortality. Unaccounted losses may be due to loss for cannibalism, unaccounted escapees, predator (birds, fishes, reptiles or mammals) other causes.

2. INDEX

$$\text{Unaccounted losses} = \frac{N^{\circ} \text{ of stocked fish} - N^{\circ} \text{ of dead fish} - N^{\circ} \text{ of harvested fish}}{N^{\circ} \text{ of stocked fish}} * 100$$

Unit measure

%

3. PARAMETERIZATION

Stocking period: 1st Quarter (JAN – MAR), 2nd Quarter (APR – JUN),
3rd Quarter (JUL – SEP), 4th Quarter (OCT- DEC)

Population level: Batch, Farm, Area

Frequency of recording: Batch: at harvest
Farm and Area: at harvest

Data input in excel form

Batch (B) and Farm (F) level

DATA INPUT		Stocking	50g	150g	250g	400g	800g	Harvest ^a
Number of stocked fish	n°	B/F						
Total mortality (n of dead fish)	n°		B/F	B/F	B/F	B/F	B/F	B/F
Estimated escapees	n°		B	B/F	B	B/F	B/F	B/F
Controlled output (sampling, movement, etc.)	n°		B	B/F	B	B/F	B/F	B/F
Number of discarded fish	n°		B	B/F	B	B/F		B/F
Number of harvested fish	n°							B/F

^a whenever harvest is performed

4. NUMERICAL VALUES OF KPI IN OTHER WORKPACKAGES AND TASKS

WP3	Task name	Leader
Task 3.5	Welfare Evaluation	ISPRA
WP6		
Task 6.1	Integrated Health Management	HCMR
Task 6.2	Feed – Growth Trial in Different Sea Bass and/or Sea Bream Stocks	HCMR

Notes

For the computation of this KPI all the registered movements during cycle of fish will be taken into account; this will include: estimated escapees, samplings, movements, discarded fish. Calculation of KPI will be done only when the batch will be completely harvested.

ID	G6
KPI	TOTAL LOSSES
DIMENSION	TECHNICAL - LOSSES

1. DEFINITION

The percentage of fish not found when counted (during handling, harvesting, sorting-counting, vaccinating) compared with the initial number of fish stocked. Is the sum of mortalities, discarded fish and unaccounted losses

2. INDEX

$$\text{Total losses} = \frac{N^{\circ} \text{ of stocked fish} - N^{\circ} \text{ of harvested fish}}{N^{\circ} \text{ of stocked fish}} * 100$$

Unit measure

%

3. PARAMETERIZATION

Stocking period: 1st Quarter (JAN – MAR), 2nd Quarter (APR – JUN),
3rd Quarter (JUL – SEP), 4th Quarter (OCT- DEC)

Population level: Batch, Farm, Area

Frequency of recording: Batch: at harvest
Farm and Area: at harvest

Data input in excel form

Batch (B) and Farm (F) level

DATA INPUT		Stocking	50g	150g	250g	400g	800g	Harvest ^a
Number of stocked fish	n°	B/F						
Controlled output (sampling, movement, etc.)	n°		B	B/F	B	B/F	B/F	B/F
Number of harvested fish	n°		B	B/F	B	B/F	B/F	B/F

^a whenever harvest is performed

4. NUMERICAL VALUES OF KPI IN OTHER WORKPACKAGES AND TASKS

WP3	Task name	Leader
Task 3.5	Welfare Evaluation	ISPRA
WP6		
Task 6.1	Integrated Health Management	HCMR
Task 6.2	Feed – Growth Trial in Different Sea Bass and/or Sea Bream Stocks	HCMR

Notes

For the computation of this KPI both the controlled output and the harvested fish will be taken into account, being both not considered as losses.

ID	G7
KPI	DISCARDED FISH AT SLAUGHTER
DIMENSION	TECHNICAL - LOSSES

1. DEFINITION

It refers to those fish that are undersized (<100 -150g) or injured during harvesting, discarded for human consumption but destined to other uses.

2. INDEX

$$\text{Discarded fish at slaughter} = \frac{\text{N}^\circ \text{ of discarded fish at slaughter}}{\text{N}^\circ \text{ of harvested fish}} * 100$$

Unit measure

%

3. PARAMETERIZATION

Stocking period: 1st Quarter (JAN – MAR), 2nd Quarter (APR – JUN),
3rd Quarter (JUL – SEP), 4th Quarter (OCT- DEC)

Population level: Batch, Farm, Area

Frequency of recording: Batch: at harvest
Farm and Area: at harvest

Data input in excel form

Batch (B) and Farm (F) level

DATA INPUT		Stocking	50g	150g	250g	400g	800g	Harvest ^a
Number of discarded fish	n°		B	B/F	B			
Number of harvested fish	n°							B/F
Number of discarded fish at slaughter	n°					B/F	B/F	B/F

^a whenever harvest is performed

4. NUMERICAL VALUES OF KPI IN OTHER WORKPACKAGES AND TASKS

WP3	Task name	Leader
Task 3.5.3	Welfare evaluation	ISPRA

Notes:

This KPI is also calculated as the sum of discarded fish during the whole production cycle, including the discarded fish registered during the periods stocking-50, 50-150, and 150-250, and discarded fish at slaughter.

Grow out - Dependency on treatments- Rationale

#ID	Dependency on treatments KPIs – A Level
G9	Number of antiparasitic treatments (total & by disease)
G10	Number of antibiotic treatments (total & by disease)
G11	Amount of active compounds - antiparasitic (total & by disease)
G12	Amount of active compounds - antibiotic (total & by disease)

The use of medicated treatments represents a critical issue in all livestock productions, including aquaculture, with implications for animal health and welfare, food safety and human health and environmental sustainability. Several scientific opinions have been produced over last years, highlighting the importance of monitoring the antimicrobial use (AMU), the evaluation of risks related to antimicrobial resistance (AMR) and the need of more transparency and cooperation among different stakeholders (FAO, 2016; EMA-EFSA 2017; OIE, 2017; WHO, 2015, 2017).

The OIE aquatic animal health code and the WHO Guidelines recommend the collection of objective and quantitative information to evaluate usage patterns by antimicrobial class, route of administration and aquatic animal species in order to evaluate exposure of microorganisms to antimicrobial agents. “The findings of surveillance and monitoring programmes should be shared at the regional and international level to maximise understanding of the global risks to aquatic animal health and human health. The publication of these data and their interpretation is important to ensure transparency (OIE)”.

The EMA and EFSA opinion (2017), which has the primary objective to reduce the AMU in the livestock industry and improve monitoring and surveillance of AMU and AMR across food-production systems, affirmed that “databases are a vital tool that underpins the benchmarking of antimicrobial use (EMA/EFSA, 2017).

Biosecurity, good practices and other measures to support prudent use of antimicrobials throughout the food chain is also a major aim of the FAO Action Plan (2016) which further supports the WHO-led Global Action Plan on Antimicrobial Resistance (2015) and highlights the necessity of adopting a “One Health” approach, with the involvement of stakeholders, including public health and veterinary authorities, food and agriculture sectors, environmental specialists and consumers.

Looking at the global aquaculture sector, there is substantially a large data gap on AMU, as regard the use in farmed fish and in the different production systems and impact on the social-ecological systems in which aquaculture takes places (Henriksson et al., 2017). The control of major diseases in sea bass and sea bream aquaculture still depends from the use of medicated treatments, due to the absence of vaccines and/or low long-term efficacy for those available, but not data are available on the AMU and AMR for MMFF sector.

Specific criteria and index have been developed (GAPI) for comparative evaluation of aquaculture systems as well as in several aquaculture certification schemes (e.g. ASC; Global G.A.P., Organic), increasing the awareness on the AMU in fish production and the public and ecosystem health risks associated with AMR.

PerformFISH will allow an important step forward and will record numerical values for estimating the **dependency of treatments for sea bream and sea bass aquaculture** sector. This will represent a first and unique exercise which involves major sea bream and sea bass aquaculture companies and producer Associations across EU, providing the sector with the opportunity to evaluate their performance and potential impact in relation to diseases control and being more transparent on AMU as it already happens in Norwegian salmon industry

The importance to acquire and update data on AMU was recognizing by PerformFISH consortium since the beginning. The set of KPIs measuring the “Dependency on antibiotic and antiparasitic treatments” was validated in the Rome meeting on November 2017 and the KPIs: number of antibiotic and antiparasitic treatments (G9, G10); amount of antibiotic and antiparasitic active compounds (G11 G12) were deemed as A-level KPIs. The number of medicated treatments, recorded as total number and by specific disease, contributes to acquire knowledge on farm health management and biosecurity and occurrence of diseases treatments over the production cycle; the overall amount of active compounds administered is also an indicator of the potential ecological impact at local and area level. This aspect is particularly relevant also in relation to the low number of drugs registered for use in aquaculture which contributes to potential phenomena of AMR due to the prolonged use of the same molecules.

In order to calculate the KPIs, companies will collect data in grow out production facilities on the basis of the listed available therapeutants (antibiotics and antiparasitics). The list was developed by ISPRA and revised by Producers Association of each country and LTPs in order to include the most important therapeutics used in sea bass and sea bream aquaculture at Mediterranean level.

Results from the benchmarking of dependency of medicated treatments will contribute in improvement the AMU for disease control and to evaluate the potential effect of sea bream and sea bass aquaculture in increasing risks for the environment and human health. The selected KPIs will further allows the benchmarking with other animal food sectors, with potential benefits on consumers perception for aquaculture products.

List of active compounds used in B&B aquaculture	
Antibiotics	Antiparasitics
β-lactam	Benzimidazolic compounds
Amoxicillin trihydrate	Fenbendazole
Ampicilin	Mebendazole
Aminoglycosides	Imidazothiazoles compounds
Apramycin	Levamisol
Apramycin sulphate	Avermectins
Tetracyclines	Ivermectine
Chlortetracycline	Aqueous solution of 37% formaldehyde*
Oxytetracycline	
Quinolones	
Enrofloxacin	
Oxolinic acid	
Sarafloxacin	
Fluoroquinolones	
Florfenicol	
Flumequin	
Macrolides	
Erythromycin	
Tilosina	
Sulphonamides	
Sulphonamides potentiated with Trimethoprin	

Table 9. List of active compounds used in B&B aquaculture * authorized only in Greece and Spain

Grow out - Dependency on treatments – KPIs Forms

ID	G9
KPI	NUMBER OF ANTIPARASITIC TREATMENTS (TOTAL & BY DISEASE)
DIMENSION	TECHNICAL & WELFARE - DEPENDENCY ON TREATMENTS

1. DEFINITION

Total number of antiparasitic treatments (medicated feed or baths) administered per production cycle.

2. INDEX

Number of antiparasitic treatments per year

Unit measure

n

3. PARAMETERIZATION

Stocking period 1st Quarter (JAN – MAR), 2nd Quarter (APR – JUN),
3rd Quarter (JUL – SEP), 4th Quarter (OCT- DEC)

Population level Batch, Farm, Area

Frequency of recording Batch: at harvest
Farm, Area: Annual reporting

Data input in excel form

Batch

DATA INPUT		Stocking	50g	150g	250g	400g	800g	Harvest ^a
Number of antiparasitic treatments	n°		✓	✓	✓	✓	✓	✓

Farm and Area level

DATA INPUT		
Number of antiparasitic treatments (total & by disease)	n°	Annual reporting

^a whenever harvest is performed

4. NUMERICAL VALUES OF KPI IN OTHER WORKPACKAGES AND TASKS

WP3	Task name	Leader
Task 3.1	Epidemiology and Health Risk Assessment	UAB
Task 3.4.	Medicines: Current Use	HCMR
Task 3.5	Welfare Evaluation	ISPRA
WP6		
Task 6.1	Integrated Health Management	HCMR

Notes:

Name of active compound used is also requested in the form for data collection on annual basis.

Reference to:

- Certification Schemes: ASC; BAP; Organic

ID	G10
KPI	NUMBER OF ANTIBIOTIC TREATMENTS (TOTAL & BY DISEASE)
DIMENSION	TECHNICAL & WELFARE - DEPENDENCY ON TREATMENTS

1. DEFINITION

Total number of antibiotic treatments (medicated feed or baths) administered per production cycle.

2. INDEX

Number of antibiotic treatment per year at farm level

Unit measure

n

3. PARAMETERIZATION

Stocking period 1st Quarter (JAN – MAR), 2nd Quarter (APR – JUN),
3rd Quarter (JUL – SEP), 4th Quarter (OCT- DEC)

Population level Batch, Farm, Area

Frequency of recording Batch: at harvest
Farm, Area: Annual reporting

Data input in excel form

Batch level

DATA INPUT		Stocking	50g	150g	250g	400g	800g	Harvest ^a
Number of antibiotic treatments	n°		✓	✓	✓	✓	✓	✓

^a whenever harvest is performed

Farm and Area level

DATA INPUT		
Number of antibiotic treatments (total & by disease)	n°	Annual reporting

4. NUMERICAL VALUES OF KPI IN OTHER WORKPACKAGES AND TASKS

WP3	Task name	Leader
Task 3.1	Epidemiology and Health Risk Assessment	UAB
Task 3.4.	Medicines: Current Use	HCMR
Task 3.5	Welfare Evaluation	ISPRA
WP6		
Task 6.1	Integrated Health Management	HCMR

Notes:

Name of active compound used is also requested in the annual data collection

Reference to:

- Certification Schemes: ASC; BAP; Organic

ID	G11
KPI	AMOUNT OF ACTIVE COMPOUNDS - ANTIPARASITIC (TOTAL & BY DISEASE)- CONFIDENTIAL TO ASSOCIATION/ISAB
DIMENSION	TECHNICAL - DEPENDENCY ON TREATMENTS

1. DEFINITION

Total amount of antiparasitic active compound per ton of fish produced

The KPI is confidential to ISAB

2. INDEX

$$\text{Amount of active compounds (antiparasitic)} = \frac{\text{Amount of antiparasitic (g)}}{\text{ton of fish}}$$

Unit measure

g/ton of fish

3. PARAMETERIZATION

Population level Farm, Area

Frequency of recording Farm and Area: Annual reporting

Data input in excel form

Farm level and Area level

DATA INPUT		
Amount of active compounds – antiparasitic (total & by disease)	g	Annual reporting
Biomass of harvested fish	Kg	Annual reporting
Biomass in stock at the end of the year	Kg	Annual reporting
Biomass in stock at the beginning of the year	Kg	Annual reporting

^awhenever harvest is performed

4. NUMERICAL VALUES OF KPI IN OTHER WORKPACKAGES AND TASKS

WP3	Task name	Leader
Task 3.1	Epidemiology and Health Risk Assessment	UAB
Task 3.4.	Medicines: Current Use	HCMR
Task 3.5	Welfare Evaluation	ISPRA
WP6		
Task 6.1	Integrated Health Management	HCMR

Notes:

The amount of fish produced in one year is calculated considering the variation of biomass in stock at the end and beginning of the year plus the harvested biomass in the year.

Name of active compound used is also requested in the annual data collection.

Information for the calculation of this KPI will include date of treatment, treated species, name of disease, name and quantity of antiparasitic active compound.

ID	G12
KPI	AMOUNT OF ACTIVE COMPOUNDS - ANTIBIOTIC (TOTAL & BY DISEASE) - CONFIDENTIAL TO ASSOCIATION/ISAB
DIMENSION	TECHNICAL - DEPENDENCY ON TREATMENTS

1. DEFINITION

Total amount of antibiotic active compounds administered per ton of fish produced

Name of product used is further request in the data collection. The KPI is confidential to ISAB

2. INDEX

$$\text{Amount of active compounds (antibiotic)} = \frac{\text{Amount of antibiotic (g)}}{\text{ton of fish}}$$

Unit measure

g/ton of fish

3. PARAMETERIZATION

Population level Farm, Area

Frequency of recording Farm and Area: Annual reporting

Data input in excel form

Farm level and Area level

DATA INPUT		
Amount of active compounds – antibiotic (total & by disease)	g/ton of fish	Annual reporting
Biomass of harvested fish	Kg	Annual reporting
Biomass in stock at the end of the year	Kg	Annual reporting
Biomass in stock at the beginning of the year	Kg	Annual reporting

^a whenever harvest is performed

4. NUMERICAL VALUES OF KPI IN OTHER WORKPACKAGES AND TASKS

WP3	Task name	Leader
Task 3.1	Epidemiology and Health Risk Assessment	UAB
Task 3.4.	Medicines: Current Use	HCMR
Task 3.5	Welfare Evaluation	ISPRA
WP6		
Task 6.1	Integrated Health Management	HCMR

Notes:

The amount of fish produced in one year is calculated considering the variation of biomass in stock at the end and beginning of the year plus the harvested biomass in the year.

Name of active compound used is also requested in the annual data collection.

Information for the calculation of this KPI will include date of treatment, treated species, name of disease, name and quantity of antibiotic active compound.

Grow out –Growth - Rationale

# ID	Growth KPIs - A-level
G13	Specific Growth Rate (SGR)
G14	Grams per day (GPD)
G15	Thermal Growth Coefficient (TGC)

Growth rate represents a key parameter in aquaculture, as it is directly linked to production costs: the faster the fish will grow during the rearing period, the shorter will last the cycles, resulting in a reduction of labor required to complete the production, a reduction of indirect costs accountable to each cycle (e.g. depreciation of equipment used for the cycle) and, on the long run and given the same number of rearing units, an increased production capacity of the farm that can increase the overall number of cycles.

Three T-KPIs have been selected for benchmarking the growth performance of farmed sea bass and sea bream, the SGR, the GPD and the TGC; these are critical management tools in fish grow-out production, because they return an immediate information about the growth performance of cultured fish, Their constant monitoring allows farm managers to take appropriate management measures in case indicators will provide evidence for growth performance below standards or expected targets (Cardia & Lovatelli, 2015)

Growth performances are directly linked to different factors, among others: quality of fingerlings (genetic), nutritional properties of feed, stocking density, feeding practices, incidence of pathologies, and environmental characteristics of the site, such as salinity and temperature profile of the water. The latter, which is independent from management decisions, moreover affects the oxygen concentration in the water (Besson et al, 2016). It is indeed a very relevant factor, intrinsic to the farm characteristics (inland farms) or location (cage farms) and the difference in water temperature between areas in the Mediterranean Sea is considered to be a major source of competitive advantages for fish farmers (Llorente and Luna, 2013).

The Thermal Growth Coefficient is a growth performance indicator that is calculated taking into account the degree days of the period between two sampling points, it is more directly influenced by the overall farm practices and management decisions and, on a lesser extent, influenced by the water temperature registered in the site, and it is used for the development of predictive growth models (Juralde et al, 2011).

Therefore, a classification of pen net farms based on their water temperature profiles will be required for a correct comparison and benchmarking, being not significant the application these growth KPIs to farms having different water temperature profiles; this issue is described in the previous chapter "*Identification of geographic areas*"

Being the growth KPIs also directly related to fish body weights, as the grow rates of small fish are higher than those registered on larger fish, the comparison and benchmarking of these performance KPIs will be also done between fish of the same size.

The comparison of growth performances within different companies and different areas in the Mediterranean basin will provide information on a parameter that has been not analyzed at a such large scale for bass and bream so far. It will also provide a reliable benchmarking of these production parameters for MMFF sector.

Grow out - Growth – KPIs Forms

ID	G13
KPI	SPECIFIC GROWTH RATE (SGR)
DIMENSION	TECHNICAL - GROWTH

1. DEFINITION

An expression of the daily growth rate (%) of body weight between two sampling dates

2. INDEX

$$\text{Specific Growth Rate (SGR)} = \left[\frac{\ln BW_1 - \ln BW_0}{t_{0-1}} \right] * 100$$

BW₀ = Initial body weight; BW₁ = Final body weight; t₀₋₁ = time interval (days)

Unit measure

% day⁻¹

3. PARAMETERIZATION

Stocking period 1st Quarter (JAN – MAR), 2nd Quarter (APR – JUN),
3rd Quarter (JUL – SEP), 4th Quarter (OCT- DEC)

Population level Batch, Farm, Area

Frequency of recording Batch: 50g, 150g, 250g, 400g, 800g/harvested batches
Farm and Area: 150g, 250g, 400g, 800g/harvested batches

Data input in excel form

Batch (B) and Farm (F) level

DATA INPUT		Stocking	50g	150g	250g	400g	800g	Harvest ^a
Date of stocking (dd/mm/yy)	date	B						
ABW at stocking	g	B/F						
ABW (at the end of period)	g			F		F	F	F
Exact ABW (at the end of period)	g		B	B	B	B	B	B
Date end of period (DD/MM/YY)	date		B	B	B	B	B	B
Average number of days of culture to reach 150g	n°			F				
Average number of days of culture to reach 400g	n°					F		
Average number of days of culture to reach 800g or total harvest	n°						F	F

^a whenever harvest is performed;

4. NUMERICAL VALUES OF KPI IN OTHER WORKPACKAGES AND TASKS

WP3	Task name	Leader
3.5	Welfare Evaluation	ISPRA
WP4		
Task 4.1.2	Determination of Recommended Levels of Specific Nutrients for Sea Bream and Sea Bass to Maximise Growth Performance and Feed Utilisation	ULPGC
Task 4.2.1	Evaluation of the Nutritional Value and Sustainability of Novel Cost Effective Alternatives to Fishmeal	HCMR
Task 4.2.2	Novel Cost Effective Lipid Sources (omega yeasts, microalgae, marine	ULPGC

	microorganisms, camelina seeds, oils, etc.)	
Task 4.2.3	Understanding and Minimizing Negative Effects of Alternative Diets on Fish Health and Welfare Anti-Nutritional Factors	HCMR
Task 4.3	Conditioning of Farmed Species to Novel Feeds to Improve Feed Utilisation, Growth and Fish Health	ULPGC
WP6		
Task 6.1	Integrated Health Management	HCMR
Task 6.2	Feed – Growth Trial in Different Sea Bass and/or Sea Bream Stocks	HCMR

Notes:

Reference to:

- Best practices and Guidelines: FISHWELL HANDBOOK (Atlantic salmon)

ID	G14
KPI	GRAMS PER DAY (GPD)
DIMENSION	TECHNICAL - GROWTH

1. DEFINITION

An expression of the fish growth expressed in grams per day between two sampling dates

2. INDEX

$$\text{Grams per day (GPD)} = \frac{(BW_1 - BW_0)}{t_{0-1}}$$

BW₀ = Initial body weight; BW₁ = Final body weight; t₀₋₁ = time interval (days)

Unit measure

% day⁻¹

3. PARAMETERIZATION

Stocking period 1st Quarter (JAN – MAR), 2nd Quarter (APR – JUN),
3rd Quarter (JUL – SEP), 4th Quarter (OCT- DEC)

Population level Batch, Farm, Area

Frequency of recording Batch: 50g, 150g, 250g, 400g, 800g/harvested batches
Farm and Area: 150g, 250g, 400g, 800g/harvested batches

Data input in excel form

Batch(B) and Farm (F) level

DATA INPUT		Stocking	50g	150g	250g	400g	800g	Harvest ^a
ABW at stocking	g	B/F						
Date of stocking (dd/mm/yy)	date	B						
ABW (at the end of period)	g			F		F	F	F
Exact ABW (at the end of period)	g		B	B	B	B	B	B
Date end of period (DD/MM/YY)	date		B	B	B	B	B	B
Average number of days of culture to reach 150g	n°			F				
Average number of days of culture to reach 400g	n°					F		
Average number of days of culture to reach 800g or total harvest	n°						F	F

^a whenever harvest is performed

4. NUMERICAL VALUES OF KPI IN OTHER WORKPACKAGES AND TASKS

WP4	Task name	Leader
Task 4.1.2	Determination of Recommended Levels of Specific Nutrients for Sea Bream and Sea Bass to Maximise Growth Performance and Feed Utilisation	ULPGC
Task 4.2.1	Evaluation of the Nutritional Value and Sustainability of Novel Cost Effective Alternatives to Fishmeal	HCMR
Task 4.2.2	Novel Cost Effective Lipid Sources (omega yeasts, microalgae, marine microorganisms, camelina seeds, oils, etc.)	ULPGC
Task 4.2.3	Understanding and Minimizing Negative Effects of Alternative Diets on	HCMR

	Fish Health and Welfare Anti-Nutritional Factors	
Task 4.3	Conditioning of Farmed Species to Novel Feeds to Improve Feed Utilisation, Growth and Fish Health	ULPGC
WP6		
Task 6.1	Integrated Health Management	HCMR
Task 6.2	Feed – Growth Trial in Different Sea Bass and/or Sea Bream Stocks	HCMR

ID	G15
KPI	THERMAL GROWTH COEFFICIENT (TGC)
DIMENSION	TECHNICAL - GROWTH

1. DEFINITION

Measure of fish weight increase based on water temperature and time requested to reach target weight

2. INDEX

$$\text{Thermal Growth Coefficient (TGC)} = \left[\frac{\sqrt[3]{BW_1} - \sqrt[3]{BW_0}}{T * t_{0-1}} \right] * 1000$$

BW₀ = Initial body weight; BW₁ = Final body weight; t₀₋₁ = time interval (days); T = average temperature in the period t₀₋₁

Unit measure

g/degree days

3. PARAMETERIZATION

Stocking period 1st Quarter (JAN – MAR), 2nd Quarter (APR – JUN),
3rd Quarter (JUL – SEP), 4th Quarter (OCT- DEC)

Population level Batch, Farm, Area

Frequency of recording Batch: 50g, 150g, 250g, 400g, 800g/harvested batches
Farm and Area: 150g, 250g, 400g, 800g/harvested batches

Data input in excel form

Batch(B) and Farm (F) level

DATA INPUT		Stocking	50g	150g	250g	400g	800g	Harvesta
Degree days	°C	B/F	B	B/F	B	B/F	B/F	B/F
Date of stocking (dd/mm/yy)	date	B						
ABW at stocking	g	B/F						
ABW (at the end of period)	g		B	B/F	B	B/F	B/F	B/F
Date end of period (DD/MM/YY)	date		B	B/F	B	B/F	B/F	B/F
Average number of days of culture to reach 150g	n°			F				
Average number of days of culture to reach 400g	n°					F		
Average number of days of culture to reach 800g or total harvest	n°						F	F

^a whenever harvest is performed;

4. NUMERICAL VALUES OF KPI IN OTHER WORKPACKAGES AND TASKS

WP4	Task name	Leader
Task 4.1.2	Determination of Recommended Levels of Specific Nutrients for Sea Bream and Sea Bass to Maximise Growth Performance and Feed Utilization	ULPGC
Task 4.2.1	Evaluation of the Nutritional Value and Sustainability of Novel Cost	HCMR

	Effective Alternatives to Fishmeal	
Task 4.2.2	Novel Cost Effective Lipid Sources (omega yeasts, microalgae, marine microorganisms, camelina seeds, oils, etc.)	ULPGC
Task 4.2.3	Understanding and Minimizing Negative Effects of Alternative Diets on Fish Health and Welfare Anti-Nutritional Factors	HCMR
Task 4.3	Conditioning of Farmed Species to Novel Feeds to Improve Feed Utilization, Growth and Fish Health	ULPGC
WP6		
Task 6.1	Integrated Health Management	
Task 6.2	Feed – Growth Trial in Different Sea Bass and/or Sea Bream Stocks	HCMR

Grow out - Feed Efficiency – Rationale

Fish feed is a major factor of aquaculture sustainability, as it affects the quality and costs of production, environmental impact and use of natural renewable resources. The progressive limitation in the availability of fish meal and fish oil worldwide, from capture based fishery and the request for more sustainable feeds, resulted in the use of alternative protein and lipid sources. The new feed formulations do not always answer to species specific needs, with negative effects on feed efficiency, growth performance, health and the environment. The level of fish meal and fish oil included in fish feed further decreased over the past years with significant implications for the nutritional quality of farmed fish (Tacon and Metian, 2015; FEAP, 2014; Sprague et al., 2016; Matos et al., 2017).

Statistical data on feed consumption in sea bream and sea bass aquaculture are not available at regional, national and sectoral levels in Europe. Calculation can be done only on the basis of estimated Feed Conversion Rate (FCR) available in literature (Tacon and Metian, 2008) and volume of production provided by FEAP.

The approach used to develop the list of KPIs considered the general principles of the FAO Code of Conduct of Responsible Fisheries (CCRF) and principles criteria included in other reference system for sustainability (e.g. GAPI, 2010; FAO, 2013; MBA Seafood Watch, 2014; GSSI, 2015).

Two TE-KPIs were selected for benchmarking the feed efficiency of farmed sea bass and sea bream. These include the economic feed conversion ratio (FCR), calculated as the ratio of feed intake to weight gain (G16) and the biological feed conversion ratio (FCR_{bio}) which also includes the biomass of lost fish (G17).

The FCR is a widely used index to assess the animal production efficiency reflecting fish feed consumption, quality of feed ingredients and the capacity of transferring the feed resources into flesh. It further gives information on the general feeding management practices and fish health. Farmed fish display a better FCR compared to terrestrial animals (Brummet, 2013), however FCR does not account for differences in feed ingredients, edible portion and nutritional quality of final product. Study on the measurement of “nutrient retention” as index of protein and calories in feed (inputs) and edible portions (outputs) in different farmed animals (Fry et al., 2018), showed that farmed Atlantic salmon, rainbow trout, have little or no efficiency benefits compared to other farmed livestock (e.g pig, cattle). Multiple measures should be computed to benchmarking the efficiency of animal productions system. For instance, based on protein inputs and outputs, a 67.2% net loss of protein is experienced during sea bass and sea bream production (MBA, 2014).

The sustainability of feed has been further considered as a criterion within the KPIs selection process. The use of fishmeal and fish oil for fish feed and the impacts on forage fish resources and marine food webs are a primary metric for assessing the use of renewable natural resources by aquaculture.

FCR, together with the use of the Forage Fish Dependency Ratio (FFDR) have been proposed within environmental KPIs to assess the environmental performance and sustainability of aquaculture productions (FAO, 2013; Volpe et al., 2013). Following the Rome meeting on KPIs and subsequent refinements, the above KPIs have been selected at level-B by aquaculture companies, to be implemented and validated in a second step. At present, the information on the origin and characteristics of marine ingredients used for sea bass and sea bream feed are often not available for aquaculture companies participating in PerformFISH benchmarking system. The TLPs will check the availability of these feed data, which should be provided by feed suppliers.

Grow out - Feed efficiency – KPIs Forms

ID	G16
KPI	FEED CONVERSION RATIO (FCR)
DIMENSION	TECHNICAL - FEED EFFICIENCY

1. DEFINITION

The ratio between the dry weight of feed fed and the weight of yield gain (FAO, 2008). In this case, fish biomass of lost animals (dead and escaped) is not included in the computation.

2. INDEX

$$\text{Feed Conversion Ratio (FCR)} = \frac{\text{Feed delivered } (t_1 - t_0)}{(\text{Biomass}_{t_1} - \text{Biomass}_{t_0} + \text{Biomass}_h)}$$

Feed delivered (t_1-t_0) = Feed delivered during the time interval

Biomass_{t1} = Final biomass; Biomass_{t0} = Initial biomass; Biomass_h = harvested biomass

Unit measure

Numerical index without unit

3. PARAMETERIZATION

Stocking period 1st Quarter (JAN – MAR), 2nd Quarter (APR – JUN),
3rd Quarter (JUL – SEP), 4th Quarter (OCT- DEC)

Population level Batch, Farm, Area

Frequency of recording Batch: 50g, 150g, 250gr, 400g, 800/harvested batches
Farm and Area: 150g, 250gr, 400g, 800/harvested batches

Data input in excel form

Batch(B) and Farm (F) level

DATA INPUT		Stocking	50g	150g	250g	400g	800g	Harvest ^a
Number of stocked fish	n°	B/F						
ABW at stocking	g	B/F						
ABW (at the end of period)	g			F		F	F	F
Exact ABW (at the end of period)	g		B	B	B	B	B	B
Feed delivered	kg		B	B/F	B	B/F	B/F	B/F
Total mortality (n of dead fish)	n°		B/F	B/F	B/F	B/F	B/F	B/F
Estimated escapees	n°		B	B/F	B	B/F	B/F	B/F
Controlled output (sampling, movement, etc.)	n°		B	B/F	B	B/F	B/F	B/F
Controlled biomass output (sampling, movement, etc.)	kg		B	B/F	B	B/F	B/F	B/F
Number of discarded fish	n°		B/F	B	B			
Number of harvested fish	n°					B/F	B/F	B/F
Biomass of harvested fish	kg					B/F	B/F	B/F
Biomass of discarded fish at slaughtering	kg					B/F	B/F	B/F

^a whenever harvest is performed

4. NUMERICAL VALUES OF KPI IN OTHER WORKPACKAGES AND TASKS

WP3	Task name	Leader
3.5	Welfare Evaluation	ISPRA
WP4		
Task 4.1.2	Determination of Recommended Levels of Specific Nutrients for Sea Bream and Sea Bass to Maximise Growth Performance and Feed Utilisation	ULPGC
Task 4.2.1	Evaluation of the Nutritional Value and Sustainability of Novel Cost Effective Alternatives to Fishmeal	HCMR
Task 4.2.2	Novel Cost Effective Lipid Sources (omega yeasts, microalgae, marine microorganisms, camelina seeds, oils, etc.)	ULPGC
Task 4.2.3	Understanding and Minimizing Negative Effects of Alternative Diets on Fish Health and Welfare Anti-Nutritional Factors	HCMR
Task 4.3	Conditioning of Farmed Species to Novel Feeds to Improve Feed Utilisation, Growth and Fish Health	ULPGC
WP6		
Task 6.1	Integrated Health Management	HCMR
Task 6.2	Feed – Growth Trial in Different Sea Bass and/or Sea Bream Stocks	HCMR

Notes:

- The calculation of biomass variation in the period, will include the harvested biomass and any other biomass moved and not lost (e.g. Controlled output)
- Reference to:
 - Benchmarking system: GSSI, FAO Guide – indicators to monitor sustainable development of aquaculture

ID	G17
KPI	BIOLOGICAL FEED CONVERSION RATIO (FCR_{BIO})
DIMENSION	TECHNICAL - FEED EFFICIENCY

1. DEFINITION

The ratio between the dry weight of feed fed and the weight of yield gain (FAO, 2008). In this case, fish biomass of lost animals (dead and escaped) is included in the computation

2. INDEX

$$\text{Biological Feed Conversion Ratio} = \frac{\text{Feed delivered } (t_1 - t_0)}{\text{Biomass}_{t_1} - \text{Biomass}_{t_0} + \text{Biomass}_h + B_{lost}}$$

Feed delivered (t_0 - t_1) = Feed delivered during time interval

Biomass_{t₁} = Final biomass; Biomass_{t₀} = Initial biomass; Biomass_h = harvested biomass; B_{lost} = Biomass lost (dead, discarded and escaped)

Unit measure

Numerical index without unit

3. PARAMETERIZATION

Stocking period

1st Quarter (JAN – MAR), 2nd Quarter (APR – JUN),
3rd Quarter (JUL – SEP), 4th Quarter (OCT- DEC)

Population level

Batch, Farm, Area

Frequency of recording

Batch: 50g, 150g, 250g, 400g, 800g/harvested batches
Farm and Area: 150g, 250g, 400g, 800g/harvested batches

Data input in excel form

Batch(B) and Farm (F) level

DATA INPUT		Stocking	50g	150g	250g	400g	800g	Harvest ^a
Number of stocked fish	n°	B/F						
ABW at stocking	g	B/F						
Feed delivered	kg		B	B/F	B	B/F	B/F	B/F
Controlled biomass output (sampling, movement, etc.)	kg		B	B/F	B	B/F	B/F	B/F
Total mortality (biomass)	kg		B	B/F	B	B/F	B/F	B/F
Estimated escapees (biomass)	kg		B	B/F	B	B/F	B/F	B/F
Biomass of discarded fish	kg		B	B/F	B			
ABW (at the end of period)	g			F		F	F	F
Exact ABW (at the end of period)	g		B	B	B	B	B	B
Total mortality (n of dead fish)	n°		B/F	B/F	B/F	B/F	B/F	B/F
Estimated escapees	n°		B	B/F	B	B/F	B/F	B/F
Controlled output (sampling, movement, etc.)	n°		B	B/F	B	B/F	B/F	B/F
Number of discarded fish	n°		B	B/F	B			
Number of harvested fish	n°					B/F	B/F	B/F
Biomass of harvested fish	kg					B/F	B/F	B/F
Biomass of discarded fish at slaughtering	kg					B/F	B/F	B/F

^awhenever harvest is performed

4. NUMERICAL VALUES OF KPI IN OTHER WORKPACKAGES AND TASKS

WP4	Task name	Leader
Task 4.1.2	Determination of Recommended Levels of Specific Nutrients for Sea Bream and Sea Bass to Maximise Growth Performance and Feed Utilisation	ULPGC
Task 4.2.1	Evaluation of the Nutritional Value and Sustainability of Novel Cost Effective Alternatives to Fishmeal	HCMR
Task 4.2.2	Novel Cost Effective Lipid Sources (omega yeasts, microalgae, marine microorganisms, camelina seeds, oils, etc.)	ULPGC
Task 4.2.3	Understanding and Minimizing Negative Effects of Alternative Diets on Fish Health and Welfare Anti-Nutritional Factors	HCMR
Task 4.3	Conditioning of Farmed Species to Novel Feeds to Improve Feed Utilisation, Growth and Fish Health	ULPGC
WP6		
Task 6.1	Integrated Health Management	HCMR
Task 6.2	Feed – Growth Trial in Different Sea Bass and/or Sea Bream Stocks	HCMR

Notes:

The calculation of biomass variation in the period, will include the harvested biomass and any other biomass moved and not lost (e.g. Controlled output), while B_{lost} will include any biomass that has been lost during the time interval (e.g. mortality, estimated escapees, discharged fish)

Grow out - Productivity – Rationale

# ID	Productivity KPIs – A - Level
G20	Biomass produced per number of FTE employees
G21	Biomass produced per volumes of sea water used

The technical efficiency of grow-out production system will be also evaluated considering two relevant T-KPIs related to productivity of the system, where the quantity of biomass produced in one year is normalized to a single Full Time Equivalent (1 employee) or the unit of rearing volume.

The reason why both efficiency and productivity should be estimated is the need for improvement of economic performance.(Coelli et al. 2005). Productivity of a farm directly affects production costs and represents a critical parameter to improve in order to increase the overall competitiveness of the company.

The quantity of fish produced by a single FTE is directly connected with the indirect cost of labor which will bear on the final production cost and the overall economic performance of the farm. Similarly, the amount of fish produced per volume of rearing unit is proportional to the technical efficiency of the farm and, therefore to the economic efficiency.

The comparison of these KPIs within a benchmarking system, where the whole grow out process is analyzed, will also highlight and quantify the direct correlation between technical efficiency and productivity.

The analysis of KPIs on productivity will finally contribute to the definition of a MMFF sector standard, which is currently not defined.

Grow out - Productivity – KPIs Forms

ID	G20
KPI	BIOMASS PRODUCED PER NUMBER OF FTE EMPLOYEES
DIMENSION	ECONOMIC - PRODUCTIVITY

1. DEFINITION

Is the ratio of growth divided by the number of employees (Full Time Equivalents – FTE)

2. INDEX

$$\text{Biomass produced per n}^\circ \text{ of FTE employees} = \frac{\text{ton of fish}}{\text{N}^\circ \text{ of employees (FTE)}}$$

Unit measure

Ton fish/FTE employee

3. PARAMETERIZATION

Population level Farm, Area

Frequency of recording Farm and Area: Annual reporting

Data input in excel form: AGGREGATED

Farm and Area level

DATA INPUT		
Biomass of harvested fish	Kg	Annual reporting
Biomass in stock at the end of the year	Kg	Annual reporting
Biomass in stock at the beginning of the year	Kg	Annual reporting
Number of "Full Time Equivalent" ¹ employees	n	Annual reporting

Notes:

The amount of fish produced in one year is calculated considering the variation of biomass in stock at the end and beginning of the year plus the harvested biomass in the year.

¹ An FTE of 1.0 is equivalent to a full-time employee.

The concept is used to convert the hours worked by several part-time employees into the hours worked by full-time employees. On an annual basis, an FTE is considered to work the total number of hours worked by a full time employee, therefore each part time employee is accounted as FTE with the following calculation:

actual number of working hours in one year of the part time employee (included paid leaves)/annual number of working hours of a full time employee (including paid leaves).

Example:

Working hours in one year for one employee of the company: 2100

Number of full time employees in the year: 5

Number of hours worked by all the part time employees during the year: 8000

Number of FTE employees= 5 + (8000/2100)= 5+3,81 = 8,81 FTE

Only employees actually working in the production process should be considered (e.g. secretaries or marketing employees have not to be included). If an employee holds different duties, only the hours spent in the production process will be taken into account.

ID	G21
KPI	BIOMASS PRODUCED PER VOLUMES OF SEA WATER USED
DIMENSION	ECONOMIC - PRODUCTIVITY

1. DEFINITION

Is the ratio between production and the volume of sea water used for growing fish

2. INDEX

$$\text{Biomass produced per volume of sea water used} = \frac{\text{ton of fish}}{\text{Sea water volume (m}^3\text{)}}$$

Unit measure

Ton fish/m³

3. PARAMETERIZATION

Population level Farm, Area

Frequency of recording Farm and Area: Annual reporting

Data input in excel form: AGGREGATED

Farm and Area level

DATA INPUT		
Volume of sea water used for growing fish for year	m ³	Annual reporting
Biomass of harvested fish	Kg	Annual reporting
Biomass in stock at the end of the year	Kg	Annual reporting
Biomass in stock at the beginning of the year	Kg	Annual reporting

Notes:

The amount of fish produced in one year is calculated considering the variation of biomass in stock at the end and beginning of the year plus the harvested biomass in the year.

Grow out - Welfare - Rationale

# ID	WE-KPIs - A-level
G1	Mortalities – total
G3	Mortalities first 3 days after transport and stocking
G4	Mortalities first 10 days after transport and stocking
G8	Vaccinated fish– by disease
G9	Number of antiparasitic treatments (total & by disease)
G10	Number of antibiotic treatments (total & by disease)
G18	Feed intake (FI)
G19	Stocking density
G22	Oxygen depletion persistence days

Improve the welfare of farmed animals responds to the ethical demand of consumers and contributes to the framework of sustainability of animal food production systems, including aquaculture (COM(2012) 6 final/2 - Strategy for the Protection and Welfare of Animals 2012-2015; CWGSAP, 2015; EFSA strategy 2020 - Trusted science for safe food; EC Food 2030). Fish welfare is indeed a strategic issue for the competitiveness and sustainability of European aquaculture (CFP Reg. EU 1380/2013; EMFF Reg. EU 508/2014) and represents a main area of the Work Programme approved by the Aquaculture Advisory Council (AAC) (FEAP Annual Report, 2017) to address welfare issues claimed by NGOs and consumer associations, which are questioning on the ethical acceptability of intensive aquaculture and claiming for the application of fish welfare indicators to document the use of animal welfare-friendly farming practices during farming, transport and at slaughter. Documenting welfare is thus an important issue for MMFF sector to provide information on the welfare of farmed sea bass and sea bream at industrial facilities and to support industry in the use of welfare indicators in their benchmarking system.

The set of WE-KPIs selected in PerformFISH covers the major areas of fish welfare (health, feeding, housing, transport,) according to the scientific literature, the principles and provisions of EU legislative framework (Dir. EC 1998/58; Dir. EC 2006/88; Dir. EU 2010/63; Reg. EC 178/2002; Reg. EC 882/2004; Reg. EC 1/2005;; Reg. EC 710/2009; Reg. EU 2016/429; the OIE standards, the EFSA Opinions and the available Code of Conducts and Best Practices). Results from EU research projects focusing on operational welfare indicators (OWIs) (e.g. WEALTH, WELLFISH, BENEFISH, COPEWELL, AQUAEXCELL) and OWIs used to assess fish welfare in other farmed species, mainly salmonids (Atlantic Salmon Welfare Handbook, NOFIMA, 2017), were investigated. The use of WE-KPIs and standards in certification schemes (e.g. ASC, Global G.A.P., BAP, RSPCA, Organic) were also considered. Methodologies for measuring welfare using index and score, developed for other animal food systems (e.g. Welfare Quality®, AWIN, for beef, dairy cattle, pigs, turkeys) and for Atlantic salmon (Welfare Index Model SWIM, Stien et al., 2013; Folkedal et al., 2016) were considered.

The first set of welfare indicators approved in the Rome meeting consisted of 28 WE-KPIs, 75% of were animal-based WE-KPIs and 25% are WE-KPIs indirect indicators. Most of selected WE-KPIs are already in use in one or more aquaculture certification schemes.

Out of 28 KPIs, a total of 9 WE-KPIs were selected at “A-level” as ready to use, taking into account their robustness, repeatability, cost-effectiveness and feasibility. **19 WE-KPIs were selected at “B-level”**, as relevant KPIs to be implemented during the project. This is the case of WE-KPIs related to the severity

injuries, the degree of parasite infestation, abnormal behavior which are within the scope of WP3 - task 3.5 Welfare evaluation for the validation of a *Methodology to assess welfare in MMFF (Deliverable 3.6, M36)*.

The set of WE-KPIs does not include indicators to measure welfare at slaughter, issue actually under debate at EU level (AAC, 2018; EU DG Health and Food Safety, report on “Welfare of farmed fish: Common practices during transport and at slaughter”, SANTE/2016/G2/009, 2017; FEAP Resolution (2011) on the welfare aspect of stunning and killing of Mediterranean farmed fish for human consumption, to respond to the pressure from NGOs which asking for higher fish welfare standard at slaughter. PerformFISH will contribute in this context through the identification and evaluation of potential application of direct and indirect OWIs related to stunning/slaughtering in the WP3 - task 3.5.

Number of selected Animal-based and indirect WE-KPIs			
WE-KPIs level	Animal-based indicators	Indirect indicators	Total
A	4	5	9
B	17	2	19
Total	21	7	28

Table 10. Selected Animal-based and indirect WE-KPIs

Number of WE-KPIs related to welfare areas						
WE-KPIs level	Health	Feeding	Housing	Transport	Slaugther	Total
A	4	1	2	2		9
B	13	5	1			19
Total	17	6	3	2		28

Table 11. WE-KPIs related to welfare areas

Grow out- Welfare – KPIs Forms

ID	G3
KPI	MORTALITIES FIRST 3 DAYS AFTER TRANSPORT AND STOCKING
DIMENSION	WELFARE

1. DEFINITION

It refers to mortalities related to transport from nursery to farm and handling stress within the first 3 days

2. INDEX

$$\text{Mortalities first 3 days after transport and stocking} = \frac{\text{N}^\circ \text{ of collected dead fish at day 3}}{\text{N}^\circ \text{ of stocked fish}} * 100$$

Unit measure

%

3. PARAMETERIZATION

Stocking period: 1st Quarter (JAN – MAR), 2nd Quarter (APR – JUN),
3rd Quarter (JUL – SEP), 4th Quarter (OCT- DEC)

Population level: Batch, Farm, Area

Frequency of recording: Batch: at day 3
Farm and Area: at day 3

Data input in excel form

Batch (B) and Farm (F) level

DATA INPUT		Stocking	50g	150g	250g	400g	800g	Harvest ^a
Number of stocked fish	n°	B/F						
Estimated number of dead fish at day 3 from stocking	n°	B/F						

^a whenever harvest is performed

4. NUMERICAL VALUES OF KPI IN OTHER WORKPACKAGES AND TASKS

WP 3	Task name	Leader
Task 3.5.3	Welfare evaluation	ISPRA
WP6		
Task 6.2	Feed – Growth Trial in Different Sea Bass and/or Sea Bream Stocks	HCMR

Notes

Reference to:

- Certification Schemes: RSPCA;
- Best practices and Guidelines: FISHWELL HANDBOOK (Atlantic salmon),

ID	G8
KPI	VACCINATED FISH - BY DISEASES
DIMENSION	TECHNICAL & WELFARE - WELFARE

1. DEFINITION

Percentage of vaccinated fish on total fish (by diseases)

2. INDEX

$$\text{Vaccinated fish (by disease)} = \frac{\text{N}^\circ \text{ of vaccinated fish by disease}}{\text{N}^\circ \text{ of stocked fish}} * 100$$

Unit measure

%

3. PARAMETERIZATION

Stocking period: 1st Quarter (JAN – MAR), 2nd Quarter (APR – JUN),
3rd Quarter (JUL – SEP), 4th Quarter (OCT- DEC)

Population level: Batch, Farm, Area

Frequency of recording: Batch: at stocking
Farm and Area: at stocking

Data input in excel form

Batch (B) and Farm (F) level

DATA INPUT		Stocking	50g	150g	250g	400g	800g	Harvest ^a
Number of stocked fish	n°	B/F						
Number of fish vaccinated against <i>V. anguillarum</i>	n°	B/F						
Number of fish vaccinated against <i>P. damsela</i>	n°	B/F						
Number of fish vaccinated against <i>Betanodavirus</i>	n°	B/F						

^awhenever harvest is performed

4. NUMERICAL VALUES OF KPI IN OTHER WORKPACKAGES AND TASKS

WP3	Task name	Leader
Task 3.1	Epidemiology and Health Risk Assessment	UAB
Task 3.3	Vaccines and Vaccination	AQUAXPRS
Task 3.5	Welfare Evaluation	ISPRA
WP6		
Task 6.1	Integrated Health Management	HCMR

Notes:

Reference to:

- Certification Schemes: RSPCA; Global G.A.P.

ID	G18
KPI	FEED INTAKE (FI)
DIMENSION	WELFARE

1. DEFINITION

Is the amount of fish feed delivered daily to each stocked fish

2. INDEX

$$\text{Feed Intake (FI)} = \frac{\text{Fish feed delivered}}{\text{Number of fish} * \text{number of days}}$$

Unit measure

g fish⁻¹day⁻¹

3. PARAMETERIZATION

Stocking period 1st Quarter (JAN – MAR), 2nd Quarter (APR – JUN),
3rd Quarter (JUL – SEP), 4th Quarter (OCT- DEC)

Population level Batch, Farm, Area

Frequency of recording Batch: 50g, 150g, 250g, 400g, 800g/harvested batches
Farm and Area: 150g, 250g, 400g, 800g/harvested batches

Data input in excel form

Batch (B) and Farm (F) level

DATA INPUT		Stocking	50g	150g	250g	400g	800g	Harvest ^a
Number of stocked fish	n°	B/F						
Feed delivered	kg		B	B/F	B	B/F	B/F	B/F
Feeding days	n°		B	B/F	B	B/F	B/F	B/F
Total mortality (n of dead fish)	n°		B/F	B/F	B/F	B/F	B/F	B/F
Estimated escapees	n°		B	B/F	B	B/F	B/F	B/F
Controlled output (sampling, movement, etc.)	n°		B	B/F	B	B/F	B/F	B/F
Number of discarded fish	n°		B	B/F	B	B/F	B/F	B/F
Number of harvested fish	n°							B/F

^a whenever harvest is performed

4. NUMERICAL VALUES OF KPI IN OTHER WORKPACKAGES AND TASKS

WP3	Task name	Leader
Task 3.5	Welfare Evaluation	ISPRA
WP4		
Task 4.1.2	Determination of Recommended Levels of Specific Nutrients for Sea Bream and Sea Bass to Maximise Growth Performance and Feed Utilisation	ULPGC
Task 4.2.1	Evaluation of the Nutritional Value and Sustainability of Novel Cost Effective Alternatives to Fishmeal	HCMR
Task 4.2.2	Novel Cost Effective Lipid Sources (omega yeasts, microalgae, marine microorganisms, camelina seeds, oils, etc.)	ULPGC
Task 4.2.3	Understanding and Minimizing Negative Effects of Alternative Diets on Fish Health and Welfare Anti-Nutritional Factors	HCMR
Task 4.3	Conditioning of Farmed Species to Novel Feeds to Improve Feed Utilisation, Growth and Fish Health	ULPGC

WP6		
Task 6.2	Feed – Growth Trial in Different Sea Bass and/or Sea Bream Stocks	HCMR

Notes:

Reference to:

- Certification Schemes: Global G.A.P.

ID	G19
KPI	STOCKING DENSITY
DIMENSION	WELFARE

1. DEFINITION

It refers to the maximum stocking density (kg/m³) routinely achieved at harvest at farm level

2. INDEX

$$\text{Stocking density} = \frac{\text{Maximum stocked biomass (kg)}}{\text{Cage volume (m}^3\text{)}}$$

Unit measure

Kg/m³

3. PARAMETERIZATION

Stocking period 1st Quarter (JAN – MAR), 2nd Quarter (APR – JUN),
3rd Quarter (JUL – SEP), 4th Quarter (OCT- DEC)

Population level Batch, Farm

Frequency of recording Batch: at harvest
Farm: at harvest

Data input in excel form

Batch (B) and Farm (F) level

DATA INPUT		Stocking	50g	150g	250g	400g	800g	Harvest ^a
Maximum stocking density	kg/m ³					B	B	B
Average maximum stocking density at farm level	kg/m ³					F	F	F

^a whenever harvest is performed

4. NUMERICAL VALUES OF KPI IN OTHER WORKPACKAGES AND TASKS

WP	Task name	Leader
Task 3.5.3	Welfare evaluation	ISPRA

Notes:

Reference to:

- Certification Schemes: BAP; Organic; RSPCA
- Welfare Index models: SWIM (Atlantic salmon)
- Best practices and Guidelines: FISHWELL HANDBOOK (Atlantic salmon)

ID	G22
KPI	OXYGEN DEPLETION PERSISTENCE DAYS
DIMENSION	WELFARE & ENVIRONMENT (Preservation of biodiversity and habitats)

1. DEFINITION

It refers to the number of days with dissolved oxygen level below 4 mg/l (EFSA, 2008) in sea water. The oxygen level has to be measured inside the farm area, in the middle of a cage, at 5m depth.

2. INDEX

Total number of days with oxygen depletion (below 4 ppm) per year

Unit measure

n

3. PARAMETERIZATION

Population level Farm

Frequency of recording Farm: Annual reporting

Data input in excel form: AGGREGATED

Farm and Area level

DATA INPUT		
Total number of days with oxygen depletion	n°	Annual reporting

Notes:

Reference to:

- Certification Schemes: ASC
- Welfare Index models: SWIM (Atlantic salmon - temperature and oxygen saturation)

Grow out – Environmental - Rationale

Aquaculture companies of all sizes are increasingly expected to report on their environmental performance and demonstrate their green credentials in a European market that is increasingly asking for environmental protection and surveillance in food-producing animal systems.

Its primary purpose of this benchmarking system based on environmental KPIs to aid companies in reporting on environmental issues and impacts, in line with what is required by the Companies rules, but also encourage Producers Associations and TLPs to take account of these environmental issues when looking at the MMFF sector strategy and the Code of Conduct (Task 7.4).

Mediterranean fish aquaculture is often seen as an economic activity potentially having impact on the natural environment through the release of organic wastes and chemicals and on biodiversity through introduction of exotic species, escapes of selectively bred stocks. Besides, reproductive and health aspects, such as genetic pollution and disease transfers, are associated with these issues (Svåsand et al., 2007; Dempster et al., 2013).

Many sea bass and sea bream companies routinely collect environmental data to report on environmental performances, either because calculated for standard organisational data or because companies reports such information to a regulator or to a certification body. At present XX of XX companies involved as TLPs with P 3,4,5,6,21 comply with certification schemes of (XX). PerformFISH encourages the TLPs of Producers associations to report on their environmental performances and to provide data for Environmental Key Performance Indicators (KPIs).

The first set of environmental KPIs (Env-KPI), proposed at the Rome meeting was develop according to the general principles of the FAO Code of Conduct of Responsible Fisheries (CCRF,1995) and using the Principle-Criteria-Indicator approach developed in Evad (Rey-Valette et al., 2008) and Indam (Fezzardi et al., 2013) projects, the following environmental principles were considered:

- Preservation of biodiversity and habitats;
- Responsible Use of Resources;
- Responsible Use of Chemical and Vet Drugs;
- Waste Management;
- Protect Aquatic Animal Health

The following criteria:

- Keep environmental impact at acceptable levels
- Keep impact on biodiversity at acceptable leves
- Dependency on renewable marine resources
- Dependency on energy
- Dependency on medicated treatment
- Reduce risks of disease transfer to wild fish
- Consumption of spaces and water
- Control of wastes at farm

Some metrics utilized in other benchmarking system (GSSI) and aquaculture certification schemes (ASC, Global GAP) to assess environmental performances of aquaculture companies, as energy efficiency, impact on habitat and biodiversity and the use of resources were presented.

This final list of 14 Environmental KPIs replaces the original 27 KPIs presented at the KPI Workshop in Rome and focuses on two main criteria: Preservation of biodiversity and habitats; use of resources.

Preservation of biodiversity and habitats

There is a strong environmental regulation in force for aquaculture industry in Europe, derived by many European-wide-regulations (WEB site Tapas, 2018), to protect the environment, conserve biodiversity and habitat and reduce environmental impact. At country level, national authorities have introduced strict enforcements regarding the siting and the licensing procedures for new aquaculture installations, the new requirements for the Environmental Impact Assessment (Directive 52/2014), the allocation of marine areas for aquaculture (FAO AZA resolution) based on the ecological approach (Aguilar-Manjarrez, 2017) and site specific environmental monitoring programme (EMP, SHoCMed, 2012; FAO Strategy for the sustainable development of Mediterranean and Black Sea aquaculture, 2018) to report on environmental impacts of industrial farming practices to regional and national Authorities

Nutrient emissions in seawater

In case of land based tanks, the EU Water Directive (2000/60, WFD) and the legislation implemented at EU country level provide the framework for the control of emission of nutrients, as nitrogen and phosphorus, from the effluents of aquaculture into water receiving bodies. In case of marine pen net systems, a wide scientific literature provides good information to estimate the potential impacts of nutrient emissions (Kalantzi et Karakassis, 2006) and confirms that the impact of nutrients on marine environment is mainly on modification of benthic species in the sediment very close to fish farm area without important effects at large scale on marine ecosystems (Karakassis et Jerez, 2011; Jerez et al., 2016; SHoCMed 2012). For this reason, two KPIs, accumulation of phosphorous and nitrogen in sediment (G26 G27), were included for grow out systems using net pen technologies. Both metrics are usually recorded on monthly, seasonal or year basis at company level, within the framework of the site-specific EMP assigned by the Authorities to the company for the farming site (FAO AZA EMP , site).

Water quality is essential for the health of farmed fish and wild species and dissolved oxygen (DO), particularly critical for the survival and good performance of farmed finfish. Hypoxia in marine farming areas may occur for particular climate and hydrodynamic conditions, including high temperature, time of day and upwelling of oxygen-poor waters from deep in marine water and for excessive nutrient loading in farming area. The Env-KPI used for monitoring oxygen depletion persistence days below safe level for fish (G22) represented overall a proxy for a water body's ability to support healthy biodiversity. It is also relevant as risk factor for health and welfare of farmed fish and it is calculated as an indirect animal welfare indicators computed for benchmarking fish welfare (G22, WE-KPI). The limit of 4 ppm DO as safe level for bass and bream was indicated as threshold according to EFSA (2009).

The KPI "Benthic impact on local biodiversity -Macrofauna index score", which provides semi quantitative index of the impact of nutrient and organic on benthic communities, was considered as a B-level KPI, being data collected at company according to different site-specific environmental monitoring programme (EMP) and using different benthic index (Shannon Index; AMBI, AZTI Marine Biotic Index; BQI- Benthic Quality Index, Reiss et Kröncke, 2005). Data on benthic impact on local biodiversity are, however, collected on annual basis by all companies within their EMPs and can provided further information to document performances of MMFF sector for the purpose of the Code of Conduct (task 7.4).

Marine Life

The set of En-KPIs identified as A-level for “Preservation of biodiversity and habitats” are 6 indicators of which 3 KPIs provide numerical values of the impacts of farming practices on marine wildlife, as interactions with marine mammals, birds, fish, reptiles, and escapees of farmed fish. Aquaculture attracts a variety of predators and wildlife and accidental and deliberate mortalities may occur for species of conservation interest. The list of endangered species of interest in PerformFISH considered the European legislative framework: the species listed in the in Annex II and Annex IV of the Habitat Directive (92/43/EEC), in the Annex I of the Birds Directive (2009/147/EC) and The Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean (SPA/BD) of the Barcelona Convention (1976), which also included threatened or endangered marine birds and six species of turtles and some species of fish and cetaceans. The “List of Concern” of protected species includes five species of seals and turtles, all species of cetaceans, some marine fish and marine birds. ISPRA will provide to the companies a simplified list of protected species to facilitate the identification of species of interests for MMFF sector.

Escapee

The growth of the MMFF industry increases the potential number of farmed fish in the wild and, consequently, the escape-related issues. Knowledge of the extent and causes of escape incidents from net pen facilities varies greatly from country to country across Europe. Several countries, such as Norway, Scotland and Ireland, have legislated reporting requirements whereby farmers are obligated to report escape incidents, their size and cause and when they occur.

In contrast, Mediterranean countries have no such requirements; thus no statistics are available on the number of escapes or the underlying causes of escapes (Seafood Watch, 2014). According to data collected within the “Prevent Impact” EU program, the main causes of escape incidents for sea bream and sea bass in the Mediterranean Sea are either biological (51.5%; e.g. net biting, predator attack) or structural failures (39.4%; e.g. cage break, mooring failure, mechanical net damage), as opposed to operational failures (6%; e.g. harvesting, grading, transport), with more incidents involving sea bream than sea bass (Jackson et al., 2015). In financial terms, Jackson et al. (2015) claimed fish escapes as a major handicap for Mediterranean fish farmers, causing annual losses of €42.8 million in small- and large-scale events (>7 million fish in 67 incidents over a 3-year study period).

Knowledge of the specific effects of escaped fish on the ecosystem is limited to Atlantic salmon (*Salmo salar*) and, to a lesser extent, Atlantic cod (*Gadus morhua*), highlighting detrimental effects on wild conspecifics and native populations (Naylor et al., 2005; Moe et al., 2007; Jensen et al., 2010). The first negative environmental impacts of escapees arise from more direct biotic interactions, which might result in serious alterations to native ecosystems. Escaped sea bream showed high adaptability to new environments. One study found that they were recaptured in natural habitats, feeding on their most common natural prey just after 1 week in the wild (Arechavala-Lopez et al., 2012). Escaped sea bream and sea bass may become the most abundant predator in shallow coastal waters within tens of kilometers from fish farms, preying on different trophic guilds such as wild fish, crustaceans and cephalopods, which are typically consumed by the autochthonous predators (Gonzalez-Lorenzo et al., 2005; Toledo-Guedes et al., 2009, 2014). Nevertheless, the potential impact of competition could be higher if escape incidents occur in areas where fish assemblages are already subjected to anthropic stressors such as overfishing, pollution or habitat degradation (Giakoumi et al., 2015), and the final

effect of the escape would be affected by the carrying capacity of the habitat regarding trophic resources and habitat complexity (Coll et al., 2013).

The potential risk of pathogen transmission via escapees in fish farming areas has been scarcely documented. The large number of pathogens affecting both cultured sea bream and sea bass, the species-specificity of certain pathogens (Raynard et al., 2007), and the fact that escaped sea bream and sea bass visit nearby farms (Arechavala-Lopez et al., 2011, 2012), increase the potential risk of disease transmission among farmed stocks (Arechavala-Lopez et al., 2013). This aspect should be very relevant if fish farms coexist in a certain area (i.e. aquaculture polygons) as a result of spatial planning decision-makers.

The possible genetic effects of escaped fish on their wild counterparts within the ecosystem has raised lot of concern. The magnitude of impact depends on several important factors, such as the wild population genetic structure and phenotypic variability (Fraser et al., 2010), the size of the local or affected population in relation to the spillover frequency (Rhymer and Simberloff, 1996), the applied breeding programme (number of selected traits and generations under selection) and broodstock origin (non-local vs. local) (Baskett et al., 2013). In the Mediterranean, sea bream and sea bass breeding programmes were initiated in the early 2000s, and at present, the majority of production relies on fingerlings sourced from hatchery-reared-domesticated broodstock. Some programmes are based on structured selective breeding with strains of eight generations under selection (Janssen et al., 2017). Genetic studies on wild sea bream populations have demonstrated contradictory results, indicating either a weak genetic structure in the Atlantic and Mediterranean Seas (Alarcon et al., 2004; De Innocentiis et al., 2004; Franchini et al., 2012) or strong genetic subdivision at short distances throughout the Mediterranean Basin (Ben-Slimen et al., 2004). On the other hand, farmed fish generally form genetically distinct groups compared to wild populations (Karaïskou et al., 2009; Loukovitis et al., 2012). In the case of European sea bass, wild population genetic differentiation has been well studied, showing evidence that some wild Mediterranean stocks may have already been affected by escapees (Bahri-Sfar et al., 2005). According to Taranger et al., (2015), the risk of introgression can be considered moderate, at least for the eastern Adriatic Sea, i.e. risk is considered high with a frequency of escapees above 10% and low below 4%.

In PerformFISH benchmarking system, fish escapes represent a component of production batches performances (Uncounted losses, G5). Estimate of small and large escape events at growth out facilities is required to get a cumulative number of escape fish along the production cycle. Escapees are calculated as number of escape episodes occurring at farm level on yearly basis, normalized by the surface area of the farm (G23) and as the estimated number of escaped fish, normalized by biomass produced in tonnes (G24). The Env-KPI G24, together with Env-KPI G24 is among those KPIs considered to address high sensitive data for MMFF sector and will firstly managed and keep confidential to Producer Associations. Numerical data for the calculation of these KPIs provided by means of the submission form will be storage in the workspace created for this scope in the PerformFISH KPI VRE.

Use of resources

At the present stage the inclusion of energy indicators and resource use indicators into the system of environmental assessments is a common trend to sustainable “green” growth. The benchmarking KPIs system included six En-KPIs to get numerical values of the use of natural resources (marine space, land and freshwater) and the use of energy and calculate

The En-KPI G28-G35 are closely related to the issues of resource deficiency, which is the biggest environmental challenge combined with climate changes facing current and future generations.

The selected key environmental performances indicators are among the essential parameters used in life cycle inventory use input and outputs and relevant for environmental impact assessment in animal food production systems (Aubin et al. 2009; Ramos, 2016; Aubin et al. 2009). Energy consumption used in food production has become a source of major public concern because of the potential impact of gaseous emissions on heat-radiation absorption in atmosphere and climate change.

Despite the importance of an efficient and sustainable energy use for fish production, there are very few data available on energy consumption in aquaculture. This issue is quite new for Mediterranean companies and the data collected in this process, will allow producers to make a first comparative energy assessments during the phase of grow-out process in cages and land based facilities. Indicators for energy consumption and specific requirements to the maximum energy of GHG emissions allowed at farm level are under analysis also in certification schemes (e.g. ASC, 2017), to raise awareness of aquaculture producers to the importance of GHG emissions.

The data inputs for the calculation of KPIs are related to 1 year period and the reference unit is the farm at gate. The system of KPIs will be used to document the resources consumed and the emissions to the environment, without any computation for the transformation of the inventory data recorded using KPIs (resources and emissions) in impact categories for environmental impact estimation. All eEn-KPIs are normalised by functional unit (ton produced) to facilitate comparison across different organisation sectors and products.

The calculation of G31-35 KPIs, only takes into account emissions coming directly from a source that is controlled by the farm/facility (eg. Fuel for boat) and emissions resulting from the generation of purchased electricity, heating, or cooling. Quantification of emissions is calculated by multiplying activity data (e.g., quantity of fuel or kwh consumed) by an emission factor (e.g., CO₂/kwh).

The calculation of GHG emissions (G35) will be computed automatically in the database using as input the data recorded for KPI 31-33.

Grow out - Environment – KPIs Forms

ID	G23
KPI	ESCAPES - NUMBER OF EPISODES
DIMENSION	ENVIRONMENT - Preservation of biodiversity and habitats

1. DEFINITION

Number of episodes of escapes, considering both small and large scale escape events of fish.

2. INDEX

$$\text{Escapes(} \textit{Number of episodes}) = \frac{\textit{Number of escapes episodes}}{\textit{ton of fish}}$$

Unit measure

n. of episodes of escape/ ton fish

3. PARAMETERIZATION

Population level Farm, Area

Frequency of recording Farm, Area: Annual reporting

Data input in excel form: AGGREGATED

Farm and Area level

DATA INPUT		
Number of episodes of escape	n	Annual reporting
Biomass of harvested fish	Kg	Annual reporting
Biomass in stock at the end of the year	Kg	Annual reporting
Biomass in stock at the beginning of the year	Kg	Annual reporting

Notes:

The amount of fish produced in one year is calculated considering the variation of biomass in stock at the end and beginning of the year plus the harvested biomass in the year.

Reference to

- Certification Schemes: Global G.A.P.; RSPCA; ASC B&B;
- Benchmarking system: GSSI

ID	G24
KPI	ESCAPES - ESTIMATED NUMBER OF ESCAPED FISH
DIMENSION	ENVIRONMENT - Preservation of biodiversity and habitats

1. DEFINITION

It refers to the estimated number of escaped fish.

2. INDEX

$$\text{Escapes}(\text{Estimated number of escaped fish}) = \frac{\text{Estimated number of escaped fish}}{\text{ton of fish}}$$

Unit measure

n. of fish / ton fish

3. PARAMETERIZATION

Population level Farm, Area

Frequency of recording Farm, Area: Annual reporting

Data input in excel form: AGGREGATED

Farm and Area level

DATA INPUT		
Estimated number of escaped fish	n	Annual reporting
Biomass of harvested fish	Kg	Annual reporting
Biomass in stock at the end of the year	Kg	Annual reporting
Biomass in stock at the beginning of the year	Kg	Annual reporting

Notes:

The amount of fish produced in one year is calculated considering the variation of biomass in stock at the end and beginning of the year plus the harvested biomass in the year.

Reference to:

- Certification Schemes: ASC
- Benchmarking system: GAPI

ID	G25
KPI	ENDANGERED MARINE MAMMALS, REPTILES, FISHES AND BIRDS LETHAL INCIDENTS
DIMENSION	ENVIRONMENT - Preservation of biodiversity and habitats

1. DEFINITION

It refers to number of the lethal incidents of endangered species (marine mammals, birds, fish and turtles).

2. INDEX

$$\text{Endangered marine mammals, reptiles, fishes and birds lethal incidents} \\ = \frac{\text{Number of lethal incidents}}{\text{ha}}$$

Unit measure

n. of lethal incident/ha/year

3. PARAMETERIZATION

Population level Farm, Area,

Frequency of recording Farm, Area: Annual reporting

Data input in excel form: AGGREGATED

Farm and Area level

DATA INPUT		
Number of lethal incidents (Marine endangered species)	n.	Annual reporting
Total marine space use for farming	ha	Annual reporting

Notes

The list of endangered species is according to Protocol concerning specially protected areas and biological diversity in the Mediterranean (Annex 2 and Annex 3), to the Habitat Directive (Annex II and IV) and the Birds Directive (Annex I).

Reference to:

- Certification Schemes: ASC; RSPCA;
- Benchmarking system: GSSI

ID	G26
KPI	PHOSPHOROUS ACCUMULATED IN SEDIMENT
DIMENSION	ENVIRONMENT - Preservation of biodiversity and habitats

1. DEFINITION

Amount of Phosphorus accumulated in seabed sediment, in the Allowable Zone of Effect (AZE), according to the data provided in the Environmental Monitoring Report by the Company level for national regulations or certification scheme adopted. This KPI will be implemented by Month 24.

2. INDEX

$$\text{Phosphorous accumulated in sediment} = \frac{P \text{ accumulated in sediment (g)}}{\text{sediment (kg)}}$$

Unit measure

g/kg of sediment

3. PARAMETERIZATION

Population level Farm

Frequency of recording Farm: EMP/Annual reporting

Data input in excel form: NONE

Notes

Reference to:

- Certification Schemes: Global G.A.P.; Organic; ASC

ID	G27
KPI	NITROGEN ACCUMULATED IN SEDIMENT
DIMENSION	ENVIRONMENT - Preservation of biodiversity and habitats

1. DEFINITION

Amount of Nitrogen accumulated in seabed sediment, in the Allowable Zone of Effect (AZE), according to the data provided in the Environmental Monitoring Report by the Company level for national regulations or certification scheme adopted. This KPI will be implemented by Month 24.

2. INDEX

$$N \text{ accumulated in sediment} = \frac{N \text{ accumulated in sediment (g)}}{\text{sediment (kg)}}$$

Unit measure

g/kg of sediment

3. PARAMETERIZATION

Population level Farm

Frequency of recording Farm: EMP/Annual reporting

Data input in excel form: NONE

Notes

Reference to:

- Certification Schemes: Organic; ASC

ID	G28
KPI	MARINE SPACE USE FOR FARMING
DIMENSION	ENVIRONMENT - Use of resources

1. DEFINITION

Total marine space occupied for fish farming to produce 1 ton of fish.

2. INDEX

$$\text{Marine space use for farming} = \frac{\text{Total marine space use for farming (ha)}}{\text{ton of fish}}$$

Unit measure

ha/ton fish

3. PARAMETERIZATION

Population level Farm, Area

Frequency of recording Farm, Area: Annual reporting

Data input in excel form: AGGREGATED

Farm and Area level

DATA INPUT		
Total marine space use for farming	ha	Annual reporting
Biomass of harvested fish	Kg	Annual reporting
Biomass in stock at the end of the year	Kg	Annual reporting
Biomass in stock at the beginning of the year	Kg	Annual reporting

Notes

It is considered as the whole area for the exclusive use of the farm and it and has to be reported as the total area included in the aquaculture license, in hectares.

The amount of fish produced in one year is calculated considering the variation of biomass in stock at the end and beginning of the year plus the harvested biomass in the year.

ID	G29
KPI	LAND USE
DIMENSION	ENVIRONMENT - Use of resources

1. DEFINITION

Total land use for farming in ha to produce 1 ton of fish.

2. INDEX

$$\text{Land use} = \frac{\text{Total arable land use for farming (ha)}}{\text{ton of fish}}$$

Unit measure

ha/ton fish

3. PARAMETERIZATION

Population level Farm, Area

Frequency of recording Farm, Area: Annual reporting

Data input in excel form: AGGREGATED

Farm and Area level

DATA INPUT		
Total arable land used for farming	ha	Annual reporting
Biomass of harvested fish	Kg	Annual reporting
Biomass in stock at the end of the year	Kg	Annual reporting
Biomass in stock at the beginning of the year	Kg	Annual reporting

Notes:

It is considered as the whole area for the exclusive use of the farm and it has to be reported as the total area included in the aquaculture license, in hectares.

The amount of fish produced in one year is calculated considering the variation of biomass in stock at the end and beginning of the year plus the harvested biomass in the year.

ID	G30
KPI	FRESHWATER USE
DIMENSION	ENVIRONMENT - Use of resources

1. DEFINITION

Total freshwater used for fish farming to produce 1 ton of fish.

2. INDEX

$$\text{Freshwater use} = \frac{\text{Total freshwater use for farming (m}^3\text{)}}{\text{ton of fish}}$$

Unit measure

m³/ ton fish

3. PARAMETERIZATION

Population level Farm, Area

Frequency of recording Farm, Area: Annual reporting

Data input in excel form: AGGREGATED

Farm and Area level

DATA INPUT		
Total volume of freshwater use for farming	m ³	Annual reporting
Biomass of harvested fish	Kg	Annual reporting
Biomass in stock at the end of the year	Kg	Annual reporting
Biomass in stock at the beginning of the year	Kg	Annual reporting

Notes:

- The term "fresh water" refers to water with zero salinity.
- It is considered as the amount of freshwater used for production phase and at slaughter, (e.g. for producing ice slurry used in stunning methods, cleaning nets and diving equipments, showers etc.)
- The amount of fish produced in one year is calculated considering the variation of biomass in stock at the end and beginning of the year plus the harvested biomass in the year.
- Reference to:
 - Benchmarking system: GSSI

ID	G31
KPI	ENERGY USED
DIMENSION	ENVIRONMENT - Use of resources

1. DEFINITION

Total Electricity used for farming in Kilojoule to produce 1 ton of fish

2. INDEX

$$\text{Energy used} = \frac{\text{Total electricity used for farming (kWh)}}{\text{ton of fish}}$$

Unit measure

kW h/ton fish

3. PARAMETERIZATION

Population level Farm, Area

Frequency of recording Farm, Area: Annual reporting

Data input in excel form: AGGREGATED

Farm and Area level

DATA INPUT		
Total electricity used for farming	kW h	Annual reporting
Biomass of harvested fish	Kg	Annual reporting
Biomass in stock at the end of the year	Kg	Annual reporting
Biomass in stock at the beginning of the year	Kg	Annual reporting

Notes:

- The amount of fish produced in one year is calculated considering the variation of biomass in stock at the end and beginning of the year plus the harvested biomass in the year.
- The quantity of energy used in the year of reference for production
- Reference to:
 - Certification Schemes: Global G.A.P.; ASC; EMAS (Reg.1221/2009, Annex IV)

ID	G32
KPI	FUEL (DIESEL AND PETROL) USED FOR TRANSPORT
DIMENSION	ENVIRONMENT - Use of resources

1. DEFINITION

Total Fuel (Diesel or Petrol) used for transport (eg. boat) to produce 1 ton of fish

2. INDEX

$$\text{Fuel (diesel or petrol) used for transport} = \frac{\text{Total fuel used for transport (l)}}{\text{ton of fish}}$$

Unit measure

L/ton fish

3. PARAMETERIZATION

Population level Farm, Area

Frequency of recording Farm, Area: Annual reporting

Data input in excel form: AGGREGATED

Farm and Area level

DATA INPUT		
Total Fuel (Diesel oil) used for transport (e.g. boats)	L	Annual reporting
Total Fuel (Petrol) used for transport (e.g. boats)	L	Annual reporting
Biomass of harvested fish	Kg	Annual reporting
Biomass in stock at the end of the year	Kg	Annual reporting
Biomass in stock at the beginning of the year	Kg	Annual reporting

Notes:

- The amount of fish produced in one year is calculated considering the variation of biomass in stock at the end and beginning of the year plus the harvested biomass in the year.
- Volume of petrol or diesel used in the year of reference for transportation (boat, truck, forklift, etc.). Only those transports related to the production process (eg. feed distribution at sea) are considered.
- Reference to:
 - Certification Schemes: ASC, EMAS (Reg.1221/2009, Annex IV)

ID	G33
KPI	FUEL (DIESEL AND PETROL) USED FOR OTHERS USES
DIMENSION	ENVIRONMENT - Use of resources

1. DEFINITION

Total fuel (Diesel) used for other uses (e.g. cooling, heating) to produce 1 ton of fish

2. INDEX

$$\text{Fuel (diesel or petrol) used for other uses} = \frac{\text{Total fuel for other uses (l)}}{\text{ton of fish}}$$

Unit measure

L/ton fish

3. PARAMETERIZATION

Population level Farm, Area

Frequency of recording Farm, Area: Annual reporting

Data input in excel form: AGGREGATED

Farm and Area level

DATA INPUT		
Total fuel (Diesel or Petrol) used for others uses (e.g. cooling, heating)	L	Annual reporting
Biomass of harvested fish	Kg	Annual reporting
Biomass in stock at the end of the year	Kg	Annual reporting
Biomass in stock at the beginning of the year	Kg	Annual reporting

Notes:

- The amount of fish produced in one year is calculated considering the variation of biomass in stock at the end and beginning of the year plus the harvested biomass in the year.
- Volume of petrol or diesel used in the year of reference for all uses except transport (cooling, heating, power supply, etc.)
- Reference to:
 - Certification Schemes: ASC, EMAS (Reg.1221/2009, Annex IV)

ID	G34
KPI	TOTAL EMISSION OF CO₂
DIMENSION	ENVIRONMENT - Use of resources

1. DEFINITION

Total emission of CO₂ to produce 1 ton of fish. Feed production not included

2. INDEX

$$\text{Total emission of CO}_2 = \frac{\text{Total emission of CO}_2 \text{ (CO}_2 \text{ ton)}}{\text{ton of fish}}$$

Unit measure

t CO₂/ ton fish

3. PARAMETERIZATION

Population level Farm, Area

Frequency of recording Farm, Area: Annual reporting

Data input in excel form

Farm and Area level

DATA INPUT		
Total electricity used for farming	kW h	Annual reporting
Total Fuel (DIESEL OIL) used for transport (eg. boats)	l	Annual reporting
Total Fuel (DIESEL OIL) used for other uses (eg. cooling, heating)	l	Annual reporting
Total Fuel (PETROL) used for transport (eg. boats)	l	Annual reporting
Total Fuel (PETROL) used for other uses (eg. cooling, heating)	l	Annual reporting
Biomass of harvested fish	Kg	Annual reporting
Biomass in stock at the end of the year	Kg	Annual reporting
Biomass in stock at the beginning of the year	Kg	Annual reporting

Notes:

- The amount of fish produced in one year is calculated considering the variation of biomass in stock at the end and beginning of the year plus the harvested biomass in the year.

Reference to:

- Certification Schem: ASC

ID	G35
KPI	USE OF RENEWABLE ENERGY
DIMENSION	ENVIRONMENT - Use of resources

1. DEFINITION

Percentage of renewable energy on total energy used.

2. INDEX

$$\text{Renewable energy} = \frac{\text{Total electricity from renewable sources used for farming (kW)}}{\text{Total electricity used for farming (kW)}} \times 100$$

Unit measure

%

3. PARAMETERIZATION

Population level Farm, Area

Frequency of recording Farm, Area: Annual reporting

Data input in excel form

Farm and Area level

DATA INPUT		
Renewable energy	%	Annual reporting

Notes:

Reference to:

- Certification Scheme: ASC, EMAS (Reg.1221/2009, Annex IV)

EXCEL FILES FOR DATA SUBMISSION FOR KPIS :INSTRUCTIONS FOR DATA RECORDING AND SUBMISSION

Introduction

Five dedicated data collection forms have been developed in MsExcel format, in order to facilitate the recording and submission of data useful for KPI calculation at different production facilities:

Hatchery – Nursery facilities

- Hatchery individual batch data collection form
- Hatchery aggregated batch data collection form

Pre-grow facility

- Pre grow data collection form

Grow Out facilities

- Grow out individual batch data collection form
- Grow out aggregated batch data collection form

Data collection is an important and unique source of information for comparative analysis and for benchmarking the performances of a given batch in the facility and between different facilities. Data will be recorded with the collaborative support of the companies (SMEs), along farming cycles and will be provided using the appropriate excel submission forms.

The following chapters provide a synthesis of the SOPs manual where instructions for users are available on how data collection and recording should be performed.

The use of the dedicated excel spreadsheets will allow a reliable and comparable values for the calculation of the set of Key Performance Indicators (KPIs) validated for hatchery, pre grow and grow out systems in PerformFISH (Task 7.1).

These forms should be considered as a parallel farm register which has been specifically designed for PerformFISH data collection, thus to be updated regularly. The success of KPI data recording will mainly depend on the traceability of batches recorded (by ID) in the excel forms and the respect of the times of batch controls scheduled during the production cycles.

The same methodology for collection and submission of data is used for the two target species of PerformFISH, European sea bass (*Dicentrarchus labrax*) and Gilthead sea bream (*Sparus aurata*).

The excel files filled with recorded data will be regularly uploaded in the personal Virtual Research Environment (VRE), hosted in the PerformFISH portal at CNR. All data will be totally confidential and analysed in anonymous way.

Data submission

The farm (or company) management has the responsibility of regularly update the excel forms, which will be uploaded periodically (or on request) in the personal VRE, were will be treated as strictly confidential and anonymized.

The file format of the excel files must be **.XLSX** before uploading it in the personal VRE

Please note: excel files have protected cells where users are not supposed to modify the content. Whenever needed, spreadsheets can be unlocked going to the menu tab “review”> “unprotect spreadsheet”

Hatchery – Nursery facilities

Structure of excel files

Two excel file are available for data entry:

One Excel file is designed for data collection for **individual batches**¹ during the hatchery production cycle. Production data will be collected at batch level.

A second type of excel file is designed to collect data of **aggregated batches**² and to provide production data at farm level.

Individual batch data collection

Excel File name: Hatchery_ Individual_Batch_Data_Entry_KPI.xls

This file contains different spreadsheets to collect general information on the hatchery facility and production data of individual batches at different time intervals. Excel spreadsheets (2-7) are named according to the scheduled times for batch control:

1. Hatchery Data: general information on the farm facility
2. Stocking: data enter related to the stocking of monitored batches
3. 500dd: data enter when the batch is controlled for swimbladder inflation (around 500dd)
4. End of weaning: data enter entered when the batch is completely weaned
5. 1200dd: data entered when the batch reaches 1200dd
6. 1800dd: data entered when the batch reaches 1800dd
7. 2400dd: data entered when the batch reaches 2400dd or when the batch is completely harvested

Data collection is performed on routine and standard hatchery production cycles of several batches. In case of PerformFISH batches the additional work requested to hatchery managers is the recording of some production data required for KPIs at fixed control times.

In the excel file "*Hatchery_ Individual_Batch_Data_Entry_KPI.xls*", each batch is identified with a single and unique ID, which will allow the traceability of the performances of the batch along the production cycle.

Timing for batch controls has been defined in degree days and has been scheduled at 5 control times during hatchery cycles: at stocking, at end weaning, at 1200, 1800 and 2400 degree days.

We recommend to report the batch data at control times above reported in order to make possible the comparison of batches' performances between batches and between hatcheries. However, whenever hatchery operations are completed out of those reporting times, data shall be entered in the spreadsheet with a extra-record information in which is reported the date of batch control, the ID batch and the set of data.

In the spreadsheets 1200dd, 1800dd and 2400dd, more than one record (spreadsheet row) can be used for an ID batch, in case a PerformFISH batch is graded and split in different sub-batches and rearing tanks (e.g. for fish size). The data of these sub-batches can be provided in the above mentioned spreadsheets as multiple records, one for each sub-batch, where every record may represent a "*size group*" of the original monitored batch. In this case, the same ID BATCH should be repeated for each

¹ **individual batch**: group of larvae coming from one or more spawning emissions collected within a 7 days period and managed in one or more hatchery tanks as a single unit, until the end of the nursery period

² **aggregated batches**: group of individual batches stocked in the same period in hatchery tanks, which data are submitted aggregated.

record as many size classes you got after grading/splitting, in order to match the multiple records with the unique BATCH ID assigned to the starting batch of fish in the “stocking” spreadsheet. NOTE: only one record per batch shall be used in the spreadsheets Stocking, 500dd and end of weaning.

Aggregated batches data collection

Excel File name: Hatchery_Aggregated_Batch_Data_Entry_KPI

This file contains different spreadsheets to collect production data of aggregated batches farmed in hatchery rearing units.

Hatchery Data: general information on the hatchery facility

Aggregated Data by period production data of aggregated batches recorded period wise

Aggregated batches data collection

Production data can be provided in a simple way by aggregating information of the batches stocked during the same period (Early period, Natural period or Late period). Thus, larval batches stocked in the same period (eg. Early), can be provided both as a single record (sum of all batches) or as multiple records for the same period. Level of aggregation of data is upon a decision of hatchery managers, according to the production protocols used at hatchery.

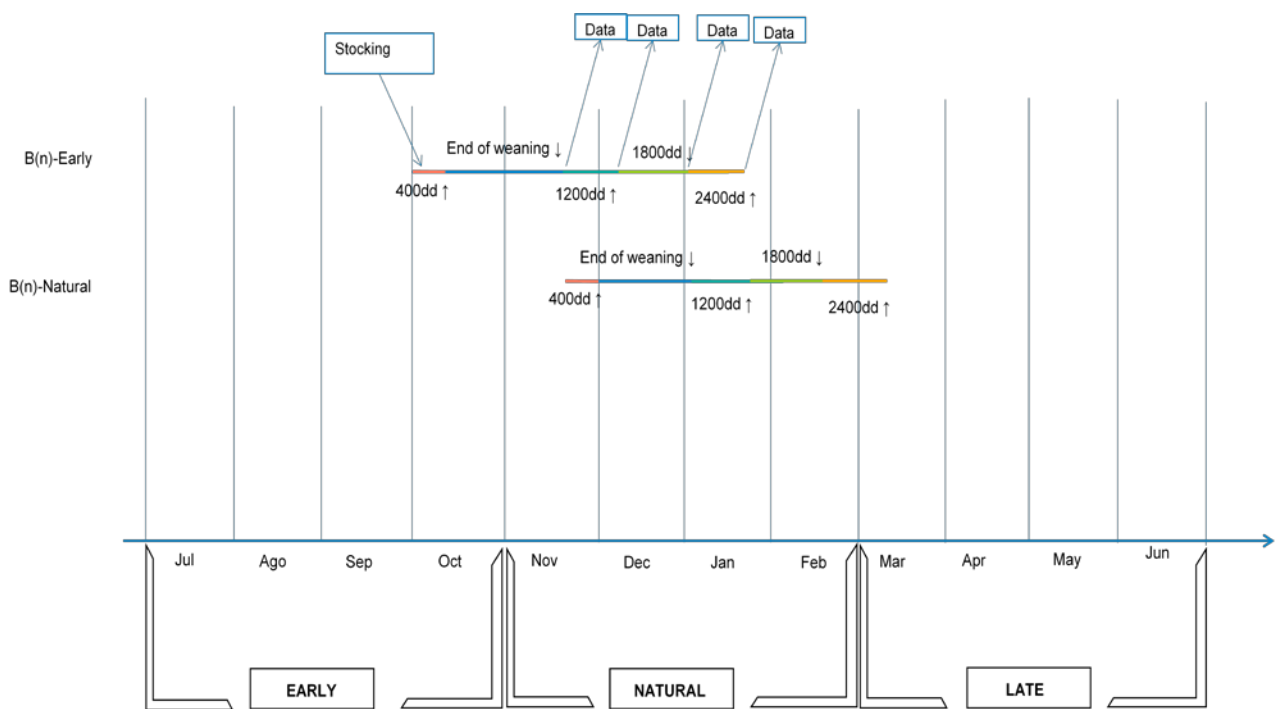


Figure 8 BATCH LEVEL - Schematic representation of a single batch cycle and data collection recorded at fixed interval

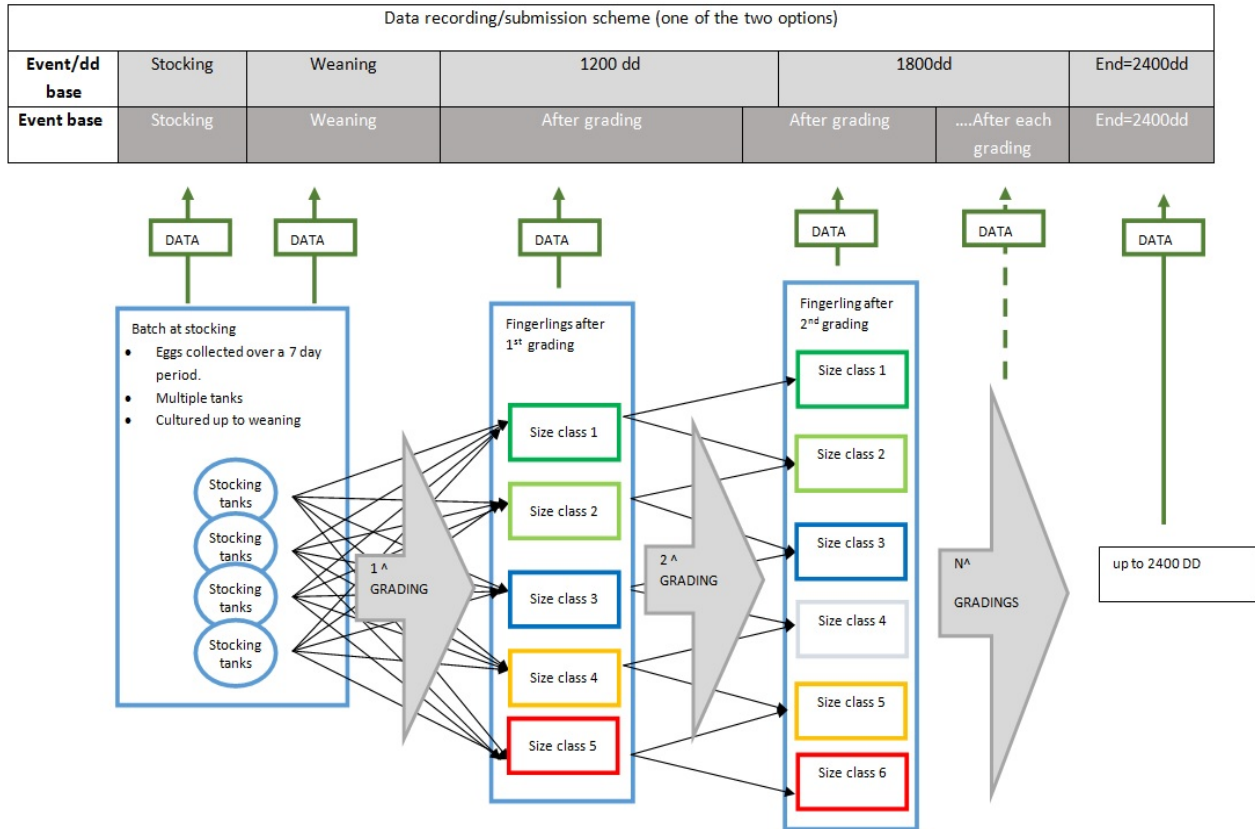


Fig. 9 BATCH LEVEL - Schematic representation of a single batch cycle and data collection recorded on an event based periods (at grading)

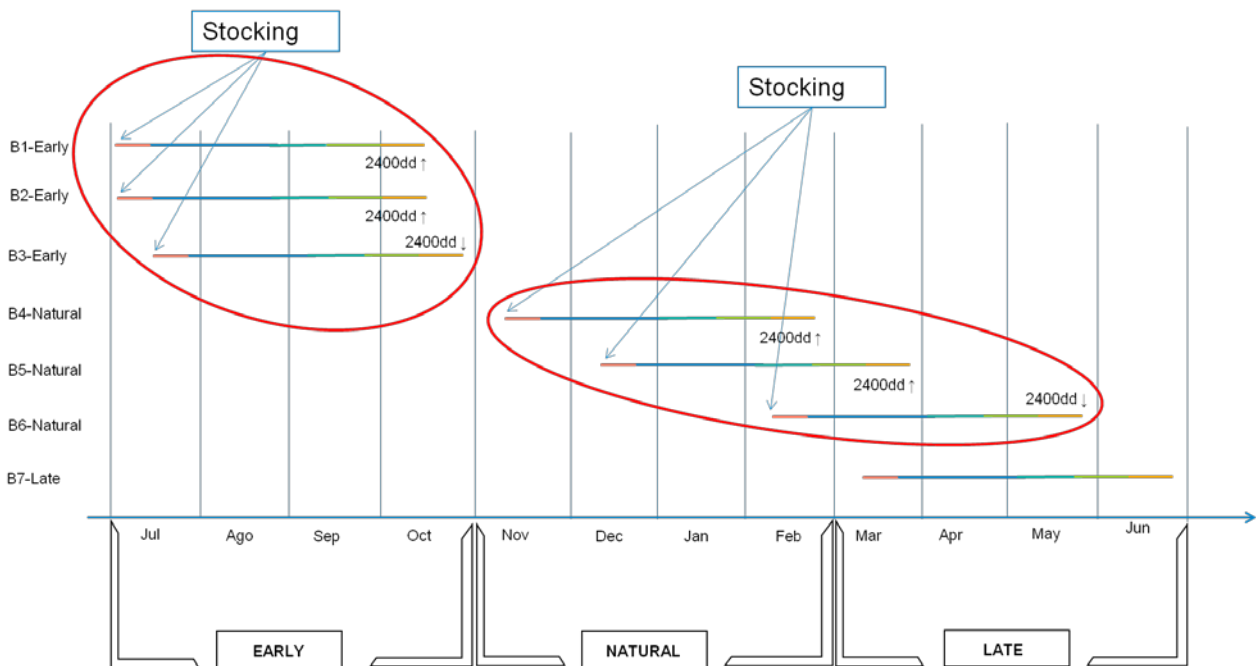


Figure 10 FARM LEVEL- Schematic representation of aggregated batches data collection

Pre-grow_facility

Structure of excel file

Excel File name: *Pre-grow_Individual_Batch_Data_Entry_KPI*

The excel file is used to collect information related to **individual batches**³ monitored during the pre-grow cycles. Data will be collected at stocking and the end of the farming cycle

Excel sheets are named:

1. **Facility Data:** general information on the farm facility
2. **Stocking data:** production data collected at stocking time, for each monitored batch
3. **End of cycle data:** production data collected at the end of the pre-grow phase, for each monitored batch
4. **Water T°C:** records of water temperature during production cycles

Individual batch data collection

Data can be entered in the data spreadsheets “when available”, for example data related to performance can be entered at stocking and then, when the monitored batch reaches the final size at the end of the cycle, before the delivery.

In the excel file “*Pre-grow_Individual_Batch_Data_Entry_KPI*”, each batch is identified with a single and unique ID, which will allow the traceability of the performances of the batch along the production cycle.

More than one record (spreadsheet row) can be used for an ID batch in case a PerformFISH batch is graded and split in different sub-batches and rearing tanks (e.g. for fish size). The data of these sub-batches can be provided in the spreadsheet as multiple records, one for each sub-batch, where every record represents a “*size group*” of the original monitored batch. In this case, the same ID BATCH should be repeated for each record as many size classes you got after grading/splitting, in order to match the multiple records with the unique BATCH ID assigned to the starting batch of fish in the “stocking” spreadsheet.

³ **individual batch:** group of fish stocked within a 7 days period and managed in one or more rearing units as a single unit, until the end of the pre-grow period

Grow Out facilities

Structure of excel files

One Excel file is for data collection for **individual batches**⁴ during the grow out production cycle. Production data will be collected at batch level:

A second type of excel file is used to collect data of **aggregated batches**⁵ and to provide production data at farm level.

Individual batch data collection

Excel File name: Grow_out_Individual_Batch_Data_Entry_KPI.xlsx

The excel file contains different spreadsheets where data on **individual batches**, farmed in one or more rearing units, can be entered at different time intervals.

Excel sheets are named according to the scheduled time for batch control:

1. **Grow out Data:** general information on the farm facility
2. **Stocking data:** production data related to the stocking of monitored batches
3. **Stocking- 50g:** production data collected from stocking to 50grams; data entered when the batch reaches 50 grams
4. **50g – 150g:** production data collected from 50 grams to 150 grams, data entered when a batch reaches 150 grams
5. **150g – 250g:** production data collected from 150 grams to 250 grams, data entered when a batch reaches 250 grams
6. **250g – 400g:** production data collected from 250 grams to 400 grams, data entered when a batch reaches 400 grams
7. **400g -800g-final harvest:** production data collected from 400 grams to 800 grams or final harvesting, data entered when a batch reaches 800 grams or when the batch is completely harvested.
8. **Water T°C :** Information on daily temperature measured in the farm

Data collection is normally performed during production cycles of all the batches in grow out. In case of PerformFISH batches, the additional work requested to farm managers is the recording of some production data required for KPIs at fixed control times.

Control times are set at defined fish sizes (stocking, 50g, 150g, 250g, 400g and 800g/harvest) and farm management should arrange data collection of each batch as much close as possible these sizes, with a tolerance of $\pm 5\%$.

In the excel file "*Grow_out_Individual_Batch_Data_Entry_KPI.xlsx*" , each batch is identified with a single and unique ID, which will allow the traceability of the performances of the batch along the production cycle.

Information on individual batches can be entered in each record of the excel file and data can be entered "when available"; for example data related to single batch performance can be entered periodically, when each monitored batch reaches the fish size at the end of each period.

⁴ **individual batch:** group of fish (fingerlings), coming from the same source, stocked in grow out within a 7 days period and managed in one or more rearing unit, until the end of the grow out cycle.

⁵ **aggregated batches:** group of individual batches reared in multiple rearing units which data are submitted aggregated according to the stocking period (1ST- 4th Quarter)

Aggregated batches data collection

Excel File name: Grow_out_Aggregated_Batch_Data_Entry_KPI.xlsx

This file contains different spreadsheets to collect production data of aggregated batches farmed in multiple rearing units.

1. **Grow out Data:** general information on the farm facility
2. **Stocking data:** information related to the stocking of monitored batches
3. **Stocking-150g :** Information on specific reference period, data entered when all the batches aggregated in the record reach 150 grams
4. **150g-400g :** Information on specific reference period, data entered when all the batches aggregated in the record reach 400 grams
5. **400g-800g-, harvest:** Information on specific reference period, data entered when all the batches aggregated in the record reach 800 grams or when are completely harvested.
6. **Water T°C:** records of water temperature during production cycles
7. **Annual Data:** data recorded for different environmental and management parameters on annual basis
8. **Sensitive data:** data recorded for the use of chemicals and for interactions of farming activities with endangered marine species.

Aggregated batches data collection

Production data can be provided in a simple way by aggregating information from multiple batches of bass or bream into single records. Aggregated batches have to be stocked during the same quarter (1ST Quarter = Jan – Mar, 2nd Quarter = Apr – Jun, 3rd Quarter = Jul – Sep, 4th Quarter = Oct - Dec)

Data are collected individually for each batch and then submitted aggregated by the farm management. Information on aggregated batches is submitted at the end of each reference period considering the slowest growing batch included in the aggregated one.

Annual data

Two spreadsheets (Annual data and Sensitive data) are designed to provide data at farm level on annual basis. These set of information is for the calculation of basic environmental and economic performances indicators. A second “ confidential” spreadsheet collected information on the use of chemicals (antibiotic and antiparasitic treatments) and the effects on biodiversity (lethal incidents to endangered species).

These set of data should be provided at the beginning of each following year for the production cycles of 2018,2019,2020.

These two spreadsheets have to be filled even if the farm management will provide production data using only the Individual Batch data submission form.

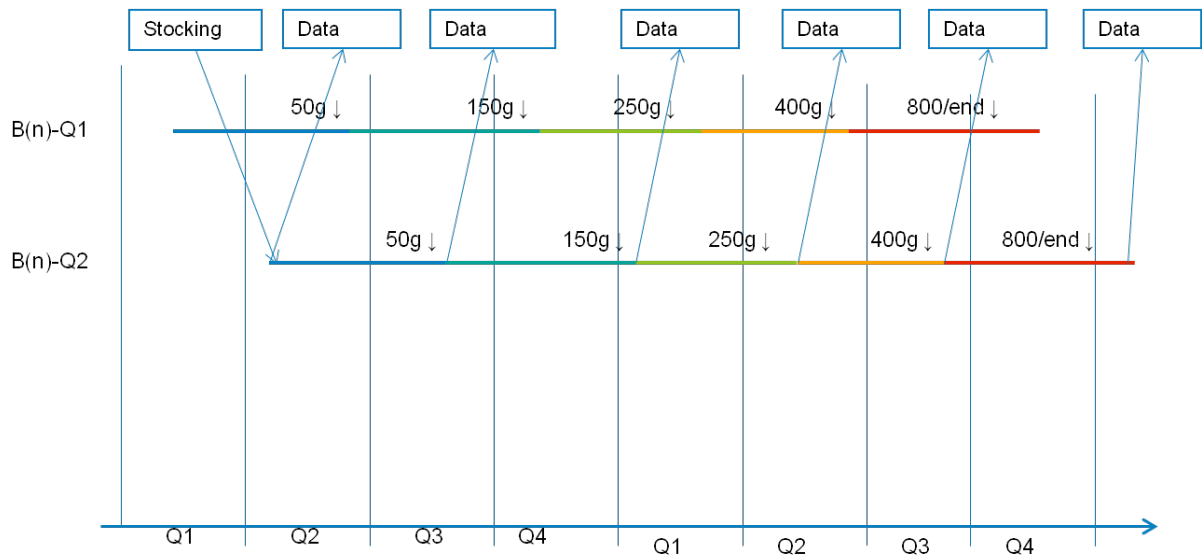


Fig. 11 BATCH LEVEL - Data collection method for different batches in relation to the quarters (sea cage/land tank) and fish fixed body weight

Data collection method: FARM scale

Data will be collected and submitted aggregated, grouping all the batches stocked in Q1, Q2, Q3 and Q4. Data will be recorded for each group of batches when the slowest-growing batch of the group will reach the target average body weight: 150g, 400g, 800g and at harvested batches and provided aggregated

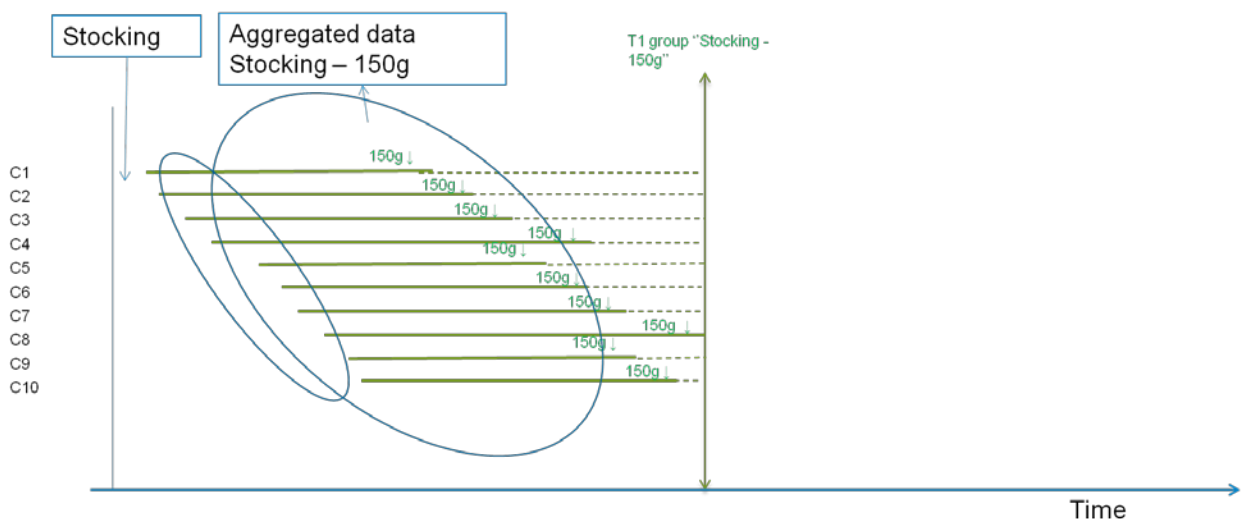


Fig. 12 FARM LEVEL - Data collection method for aggregated batches on the period from stocking to 150g over the all quarters

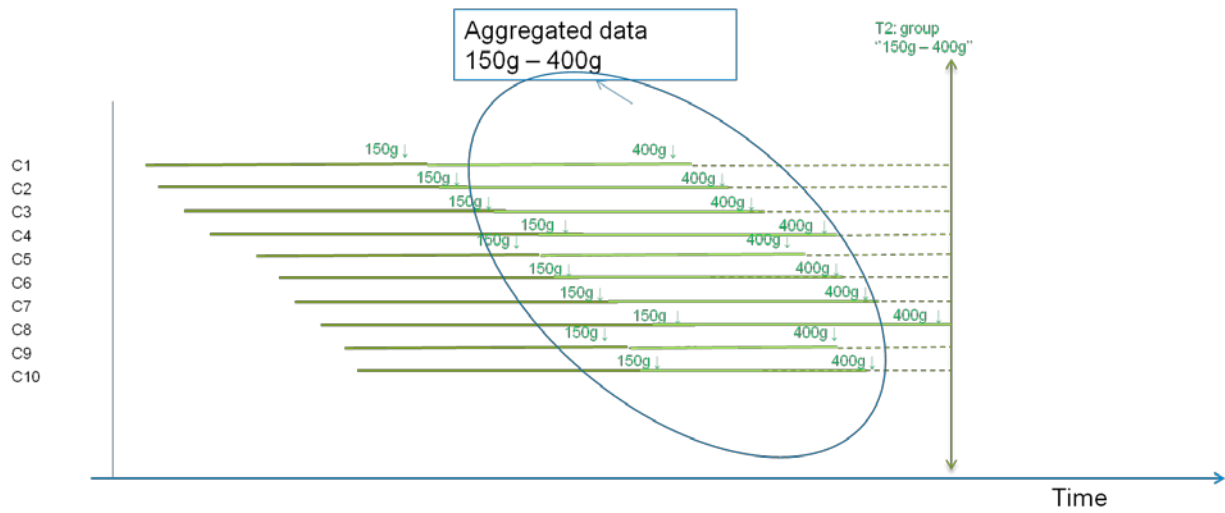


Fig. 13 FARM LEVEL - Data collection method for aggregated batches on the period from 150g to 400 g over the all quarter

SYNTHESIS OF KPIS BENCHMARKING SYSTEM

# ID	KPI	Unit measure	Formula	Frequency Batch level	Frequency Farm level
H1	Weaned fish	%	$\frac{N^{\circ} \text{ of weaned fish}}{N^{\circ} \text{ of larvae at 1 dph}} * 100$	At end of weaning	At end of weaning
H2	Deformed fish	%	$\frac{N^{\circ} \text{ of deformed fish}}{N^{\circ} \text{ of larvae at 1 dph}} * 100$	at 1200 dd at 1800 dd at 2400 dd	at 2400 dd
H3	Discarded slow grower fish	%	$\frac{N^{\circ} \text{ of discarded fish}}{N^{\circ} \text{ of larvae at 1 dph}} * 100$	at 1200 dd at 1800 dd at 2400 dd	at 2400 dd
H4	Fish produced	%	$\frac{N^{\circ} \text{ of produced fish}}{N^{\circ} \text{ of larvae at 1 dph}} * 100$	at 2400 dd at end of cycle	at 2400 dd
H5	Fish produced per FTE employees	Million fish / FTE employees	$\frac{N^{\circ} \text{ of millions of fish produced}}{N^{\circ} \text{ of employees (FTE)}}$	at 2400 dd	at 2400 dd
H6	Survival estimation	%	$\frac{N^{\circ} \text{ of fish alive}}{N^{\circ} \text{ of larvae at 1 dph}} * 100$	at 1200 dd at 1800 dd at 2400 dd	at 2400 dd
H7	Head deformities	%	$\frac{N^{\circ} \text{ of fish with head deformities}}{N^{\circ} \text{ of larvae at 1 dph}} * 100$	at end of weaning at 2400 dd	at end of weaning at 2400 dd
H8	Spinal deformities	%	$\frac{N^{\circ} \text{ of fish with spinal deformities}}{N^{\circ} \text{ of larvae at 1dph}} * 100$	at end of weaning at 2400 dd	at end of weaning at 2400 dd

H9	Fin deformities	%	$\frac{N^{\circ} \text{ of fish with fin deformities}}{N^{\circ} \text{ of larvae at 1 dph}} * 100$	at end of weaning at 2400 dd	at end of weaning at 2400 dd
H10	Swim bladder non inflation	%	$\frac{N^{\circ} \text{ of fish with non inflated SB}}{N^{\circ} \text{ of larvae at 1dph}} * 100$	at 500 dd	at 500 dd
H11	Average body weight (BW)	g	$\frac{\text{Total weight}}{N^{\circ} \text{ of fish}}$	At end of weaning at 1200 dd at 1800 dd at 2400 dd	
H12	Specific Growth Rate (SGR)	% day ⁻¹	$\left[\frac{\ln BW_1 - \ln BW_0}{t} \right] * 100$ BW ₀ = Initial body weight; BW ₁ = Final body weight t = time interval (days)	at 1200dd at 1800dd at 2400dd	
H13	Artemia requirement	Kg of artemia/million fish	$\frac{\text{Amount of Artemia used (kg)}}{\text{Millions of fish produced}}$	At end of weaning	At end of weaning
H14	Rotifers requirement	Billions/million fish	$\frac{\text{Amount of Rotifer used (Billions)}}{\text{Millions of fish produced}}$	At end of weaning	At end of weaning
H15	Vaccinated fish by disease	%	$\frac{N^{\circ} \text{ of vaccinated fish (e.g. P. damselae)}}{N^{\circ} \text{ of produced fish}} * 100$	at 2400 dd	at 2400 dd

Table 12. Synthesis of KPIs benchmarking system for Hatchery

# ID	KPI	Unit measure	Formula	Frequency Batch level
P1	Deformed fish	%	$\frac{N^{\circ} \text{ of deformed fish}}{N^{\circ} \text{ of stocked fish}} * 100$	End of cycle
P2	Discarded slow grower fish	%	$\frac{N^{\circ} \text{ of discarded fish}}{N^{\circ} \text{ of stocked fish}} * 100$	End of cycle
P3	Mortalities - total	%	$\frac{N^{\circ} \text{ of collected dead fish}}{N^{\circ} \text{ of stocked fish}} * 100$	End of cycle
P4	Specific Growth Rate (SGR)	% day-1	$\left[\frac{\ln BW_1 - \ln BW_0}{t} \right] * 100$ <p>BW₀ = Initial body weight; BW₁ = Final body weight; t = time interval (days)</p>	End of cycle
P5	Feed Conversion Ratio (FCR)	Numerical index without unit	$\frac{\text{Feed delivered } (t_1 - t_0)}{(Biomass_1 - Biomass_0)}$ <p>Feed delivered(t₁-t₀)= Feed delivered during time interval Biomass₀=Initial biomass; Biomass₁=Final biomass</p>	End of cycle

Table 13. Synthesis of KPIs benchmarking system for Pre grow

# ID	KPI	Unit	Index	Frequency*	Population	Period
G1	Mortalities - total	%	$\frac{N^{\circ} \text{ of collected dead fish}}{N^{\circ} \text{ of stocked fish}} * 100$	At fixed body weight	Batch/Farm/Area	Quarters
G2	Mortalities - by disease	%	$\frac{N^{\circ} \text{ of dead fish by disease}}{N^{\circ} \text{ of stocked fish}} * 100$	At fixed body weight	Batch/Farm/Area	Quarters
G3	Mortalities first 3 days after transport and stocking	%	$\frac{N^{\circ} \text{ of collected dead fish at day 3}}{N^{\circ} \text{ of stocked fish}} * 100$	At day 3 after transport and stocking	Batch/Farm/Area	Quarters
G4	Mortalities first 10 days after transport and stocking	%	$\frac{N^{\circ} \text{ of collected dead fish at day 10}}{N^{\circ} \text{ of stocked fish}} * 100$	At day 10 after transport and stocking	Batch/Farm/Area	Quarters
G5	Unaccounted losses	%	$\frac{N^{\circ} \text{ of stocked fish} - N^{\circ} \text{ of dead fish} - N^{\circ} \text{ of harvested fish}}{N^{\circ} \text{ of stocked fish}} * 100$	At harvest	Batch/Farm/Area	Quarters
G6	Total losses	%	$\frac{N^{\circ} \text{ of stocked fish} - N^{\circ} \text{ of harvested fish}}{N^{\circ} \text{ of stocked fish}} * 100$	At harvest	Batch/Farm/Area	Quarters
G7	Discarded fish at slaughter	%	$\frac{N^{\circ} \text{ of discarded fish at slaughter}}{N^{\circ} \text{ of harvested fish}} * 100$	At harvest	Batch/Farm/Area	Quarters
G8	Vaccinated fish - by diseases	%	$\frac{N^{\circ} \text{ of vaccinated fish by disease}}{N^{\circ} \text{ of stocked fish}} * 100$	At stocking	Batch/Farm/Area	Quarters
G9	Number of antiparasitic treatments (total & by disease)	n	<i>Number of antiparasitic treatments per batch or per year at farm level</i>	At harvest ¹ Annual reporting ²	Batch ¹ /Farm ² /Area ²	Quarters ¹ Year ²

G10	Number of antibiotic treatments (total & by disease)	n	<i>Number of antibiotic treatments per batch or per year at farm level</i>	At harvest ¹ Annual reporting ²	Batch ¹ /Farm ² /Area ²	Quarters ¹ Year ²
G11	Amount of active compounds – antiparasitic (total & by disease)	g/ton of fish	$\frac{\text{Amount of antiparasitic (g)}}{\text{ton of fish}}$	Annual reporting	Farm/Area	Year
G12	Amount of active compounds – antibiotic (total & by disease)	g/ton of fish	$\frac{\text{Amount of antibiotic (g)}}{\text{ton of fish}}$	Annual reporting	Farm/Area	Year
G13	Specific Growth Rate (SGR)	% day ⁻¹	$\left[\frac{\ln BW_1 - \ln BW_0}{t_{0-1}} \right] * 100$ BW ₀ = Initial body weight; BW ₁ = Final body weight; t ₀₋₁ = time interval (days)	At fixed body weight	Batch/Farm/Area	Quarters
G14	Grams per day (GPD)	g day ⁻¹	$\frac{(BW_1 - BW_0)}{t_{0-1}}$ BW ₀ = Initial body weight; BW ₁ = Final body weight; t ₀₋₁ = time interval (days)	At fixed body weight	Batch/Farm/Area	Quarters
G15	Thermal Growth Coefficient (TGC)	g/degree days	$\left[\frac{\sqrt[3]{BW_1} - \sqrt[3]{BW_0}}{T * t_{0-1}} \right] * 1000$ BW ₀ = Initial body weight; BW ₁ = Final body weight; t ₀₋₁ = time interval (days); T = temperature	At fixed body weight	Batch/Farm/Area	Quarters
G16	Feed Conversion Ratio (FCR)	Numerical index without unit	$\frac{\text{Feed delivered (} t_1 - t_0 \text{)}}{(Biomass_{t_1} - Biomass_{t_0} - Biomass_h)}$ Feed delivered (t ₁ -t ₀)=Feed delivered during time interval; Biomass _{t1} =Final biomass; Biomass _{t0} =Initial biomass; Biomass _h =harvested biomass	At fixed body weight	Batch/Farm/Area	Quarters

G17	Biological Feed Conversion Ratio (FCR_{BIO})	Numerical index	$\frac{\text{Feed delivered } (t_1 - t_0)}{(Biomass_{t_1} - Biomass_{t_0}) + B_h + B_{lost}}$ <p>Feed delivered (t₁-t₀)=Feed delivered during time interval; Biomass_{t₁}=Final biomass; Biomass_{t₀}=Initial biomass; B_h=harvested biomass; B_{lost}=biomass lost</p>	At fixed body weight	Batch/Farm/Area	Quarters
G18	Feed Intake (FI)	g fish ⁻¹ day ⁻¹	$\frac{\text{Fish feed delivered}}{\text{Number of fish} * \text{number of days}}$	At fixed body weight	Batch/Farm/Area	Quarters
G19	Stocking density	Kg/m ³	$\frac{\text{Maximum stocked biomass (kg)}}{\text{Cage volume (m}^3\text{)}}$	At harvest	Batch/Farm	Quarters
G20	Biomass produced per number of FTE employees	ton/FTE employee	$\frac{\text{ton of fish}}{N^{\circ} \text{ of employees (FTE)}}$	Annual reporting	Farm/Area	Year
G21	Biomass produced per volumes of sea water used	ton/m ³	$\frac{\text{ton of fish}}{\text{Sea water volume (m}^3\text{)}}$	Annual reporting	Farm/Area	Year
G22	Oxygen depletion persistence days	n	<i>Total number of days with oxygen depletion(below 4 ppm)</i>	Annual reporting	Farm	Year

G23	Escapes - Number of episodes	n. of episodes of escapes / ton fish	$\frac{\text{Number of escape episodes}}{\text{ton of fish}}$	Annual reporting	Farm/Area	Year
G24	Escapes - estimated number of escaped fish	n. of fish / ton fish	$\frac{\text{Estimated number of escaped fish}}{\text{ton of fish}}$	Annual reporting	Farm/Area	Year
G25	Endangered marine mammals, reptiles, fishes and birds lethal incidents (n. of lethal incident/ ha	$\frac{\text{Number of lethal incidents}}{\text{ha}}$	Annual reporting	Farm/Area	Year
G26	Phosphorous accumulated in sediment	g/kg of sediment	$\frac{P \text{ accumulated in sediment (g)}}{\text{sediment (kg)}}$	Annual reporting or EMP	Farm	Year or EMP
G27	Nitrogen accumulated in sediment	g/kg of sediment	$\frac{N \text{ accumulated in sediment (g)}}{\text{sediment (kg)}}$	Annual reporting or EMP	Farm	Year or EMP
G28	Marine space use for farming	ha/ton fish	$\frac{\text{Total marine space use for farming (ha)}}{\text{ton of fish}}$	Annual reporting	Farm/Area	Year
G29	Land use	ha/ton fish	$\frac{\text{Total arable land use for farming (ha)}}{\text{ton of fish}}$	Annual reporting	Farm/Area	Year

G30	Freshwater use	m ³ / ton fish	$\frac{\text{Total freshwater use for farming (m}^3\text{)}}{\text{ton of fish}}$	Annual reporting	Farm/Area	Year
G31	Energy used	Kilojoule /ton fish	$\frac{\text{Total electricity used for farming (kJ)}}{\text{ton of fish}}$	Annual reporting	Farm/Area	Year
G32	Fuel (Diesel or petrol) used for transport	L/ton fish	$\frac{\text{Total fuel used for transport (l)}}{\text{ton of fish}}$	Annual reporting	Farm/Area	Year
G33	Fuel (Diesel or petrol) used for others uses	L/ton fish	$\frac{\text{Total fuel for other uses (l)}}{\text{ton of fish}}$	Annual reporting	Farm/Area	Year
G34	Total emission of CO2	t CO ₂ / ton fish	$\frac{\text{Total emission of CO}_2 \text{ (CO}_2 \text{ ton)}}{\text{ton of fish}}$	Annual reporting	Farm/Area	Year
G35	Use of renewable energy	%	$\frac{\text{Ren. energy}}{\text{Total electricity used for farming (kW)}} \times 100$	Annual reporting	Farm/Area	Year

Table 14. Synthesis of KPIs benchmarking system for Grow out

*Fixed body weight:

BATCH level - Body weight classes : 5-50g, 51-150g, 151-250gr, 251-400g, 401-800/harvested batches

FARM/AREA level - Body weight classes: 150g, 250gr, 400g, 800/harvested batches

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